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THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

Art. XXIX.—*A Telephone Relay;* by John Trowbridge.

In histories of the invention of telegraphy much stress is placed upon the invention of the telegraphic relay; for it seemed doubtless to Joseph Henry and to Morse a complete apparatus for indefinite extension of the telegraph over land. In the progress of the telegraphic art, due to better lines and improved instruments, the telegraphic relay has lost the pre-eminent position it once occupied in men's minds; and the long discussions in the various treatises on the development of the art of telegraphy, in regard to the priority of the invention of the relay, have ceased to interest practical electricians.

It is natural, with the introduction of telephony, that attention should be directed to an analogous problem, that of the telephonic relay; a far more difficult problem than the telegraphic relay; and the future historian of the progress of telephony will find it difficult to analyze the work of hundreds of inventors who have sought to solve the problem.

When we consider that the telegraphic relay merely responds to one throb, so to speak, one inarticulate impulse, while a telephonic relay must reproduce the whole range of the human voice, we begin to realize the demand that the invention of such a relay must make upon both scientific knowledge of sound and of electricity and magnetism; and above all, upon mechanical skill. It does not, therefore, seem inappropriate to discuss in this Journal, which contains much of the work of Joseph Henry, some scientific points in connection with a telephonic relay.

The earlier inventors who attacked the problem naturally thought of the simple device of applying a microphonic contact immediately to the vibrating diaphragm of a telephone,

hoping to repeat the almost infinitesimal vibrations of this diaphragm, and to give them an increase of energy by a local battery. This attempt is an application pure and simple of the principle of the telegraphic relay and therefore marks no progress in the art; for it was not new in principle and furthermore it did not work. The application of the microphonic contact loaded the diaphragm at its most sensitive point and thus prevented the vibrations which one sought to repeat; moreover, the vibrations of the diaphragm are too minute to cause a sufficient agitation of the microphonic contact.

The next step in the mind of the inventor was to endeavor to increase the vibration of the center of the telephonic diaphragm by a lever. This arrangement was found to be inoperative, for the short arm of the lever exercised a prejudicial pressure on the vibrating diaphragm; moreover, the fundamental vibrations of the lever were superposed on the vibrations of the diaphragm, thus completely confusing speech.

It was perhaps natural to suppose that a number of microphonic contacts placed on a number of telephonic diaphragms, the telephones being arranged one after the other in tandem, might gather, so to speak, the slight vibrations of each and throw them in a united volume upon the relay line. This chorus arrangement, however, is also a failure; for the united speech is confused; much as if a number of persons singing the same note, some through the nose and others imperfectly, should undertake to transmit the note through a number of telephones. The imperfection of each microphonic contact disturbs the final result.

It must be remembered that the telephone is after all an imperfect instrument and its wonderful adaptiveness is greatly aided by the human brain, which catches at the connection of thought. This can be seen if individual words are transmitted without context. It will be found that the call girl will ask you to repeat such a collocation as "superstitious zoological veneration." Moreover the amount of energy utilized in the telephone is extremely small; most of the energy of the currents which actuate it and transmit speech is dissipated in heat. Some observers think that less than one per cent of the energy of such currents is transformed into sound waves. We see, therefore, that the problem of the telephone relay calls for all our electrical and mechanical aids to preserve and to transmit this small percentage.

Since mechanical enlargement of the vibration of the telephonic diaphragm by levers is out of the question, the next more promising step seemed to be the bringing in, so to speak, of electromagnetic energy, and it has been proposed to cause the telephonic currents on the circuit to be relayed, to react by

induction on a neighboring circuit at several points. This method gets rid of mechanical pressure on the vibrating diaphragm of the telephone, and substitutes an electrical pressure without any visible connection between the circuits. This method also is ineffective. It has, however, a certain analogy in another and more successful attempt to utilize an invisible and intangible magnetic effect without bringing a mechanical pressure on the telephonic diaphragm; this method consists in causing the telephonic currents to disturb a piece of iron, a balanced magnet, or a suspended coil in a strong magnetic field such as is found at the center of an electromagnet or between the poles of a strong permanent magnet.

The principle of this method is that of the siphon recorder, the invention of Lord Kelvin, which is used on ocean cables. Since the current on the cable is very feeble, and cannot work ordinary telegraphic instruments, some method must be used to magnify or to record the signals. The method adopted by Lord Kelvin was that of a delicately suspended coil so placed between the poles of a powerful magnet that when the feeble currents passed through this coil it oscillated; for the feeble currents animated the coil making it an electromagnet, the poles of which sought the poles of the powerful stationary magnet. Thus a very feeble electrical current could be detected by the powerful magnetic influence to which it was subjected. Here we have a mechanical movement, the movement of a vibrating system, produced without the intermediation of visible connecting parts. The same principle has been adopted in many forms of instruments for detecting and measuring electrical currents, both in laboratories and in commercial electrical installations.

It has, therefore, occurred to many minds that by the use of this principle of magnifying the vibration of moving parts by the reaction between the feeble currents in such parts and the environment about these parts, one should be able to strengthen or repeat such vibrations. The mechanical difficulties, however, are very great if one endeavors to apply this principle to the problem of the telephonic relay. A delicate suspension such as is used in the siphon recorder or the D'Arsonval galvanometer is out of the question; and a rigid suspension prevents the turning movement, the seeking of the poles of the powerful magnet by the little coil which conveys the feeble currents. A certain measure of success, however, can be obtained by careful adjustments in a laboratory; but the utilization of the turning movement of a little coil in a magnetic field has not yet proved of commercial use in telephony.

We are apparently brought back to some modification of the simple principle of the disturbance of a powerful magnetic

field by the effect of feeble currents circulating around coils placed in such fields. Suppose, for instance, that we have a hollow electromagnet with another electromagnet suspended above it, the iron core of the suspended magnet forming a part of the core of the stationary more powerful electromagnet. The system can evidently be balanced, in various ways; for instance, the suspended magnetic core can be maintained in a definite position by connection with a telephone diaphragm; and when a feeble current circulates through the coil of such a suspended electromagnet its position with respect to the stationary coil is changed. Instead of the diaphragm of a telephone, it is evident that a diaphragm connected to a microphonic contact can be employed. This idea can be found in the efforts of many inventors to construct a relay. Professor Dolbear has described a telephone which works upon this principle; a non-magnetic diaphragm placed close to the pole of a permanent magnet carries a little electromagnet which is balanced under the influence of the elasticity of the diaphragm and the magnetism of the permanent magnet. When the voice causes the diaphragm to vibrate, the movements of the little electromagnet disturb the magnetic field, producing feeble currents of induction in the little moving coil which transmit speech to a similar piece of apparatus. If this similar receiving apparatus of Professor Dolbear had been employed to modify a microphonic contact, it would have been the precursor of many subsequent inventions.

Instead, therefore, of the turning or torsional effect relied upon to actuate Lord Kelvin's siphon recorder,—called "Siphon" because a siphonic pen records the oscillations of the vibrating coil,—we have efforts to utilize the to and fro thrust of a vibrating core of an electromagnet whose position in a powerful field is modified by the strength of the feeble telephonic currents which circulate around the core of such a magnet.

At first sight it would seem that the inertia of the suspended electromagnet, or that of its core or plunger if the coil of the electromagnet is fixed, would be so great that the motion of the microphonic contacts would be seriously impeded. It is true that the weight of the vibrating parts in this form of relay must be small, and there must not be any subsidiary vibrations of the moving parts which might be superposed upon the vibrations due to the telephonic currents. It is evident that such subsidiary vibrations can arise if the moving parts are long and of considerable size. With a loaded microphonic contact we can have feeble effects or roaring sounds, as if the membrane of the ear is loaded by an obstruction.

In this form of telephonic relay we, therefore, have a microphonic contact connected with what may be called an iron plunger, the position of which in a magnetic field is modified by changes in its magnetism by surrounding feeble telephonic currents. The only mechanical connection is that of this moving plunger with the microphonic contact.

The magnetic part of a relay embodying the above ideas can be suitably constructed so as to perform their part to a commercial degree of perfection; the principal imperfection of the relay arises from the microphonic part. Among such imperfections the most notable one is the roaring or "growling" of the microphone when a strong battery is used to get the greatest degree of sensitiveness from it. This noise, which arises in great part from crepitations produced by heat, can completely overpower telephonic transmission of speech. This crepitation is greatly enhanced by the direct connection of the plunger or moving electromagnetic coil with the microphonic contact; for the movements in the magnetic field and the crepitations in the microphone get into a swing together, mutually aiding each other. This mutual action is one of the greatest barriers to the perfection of a telephonic relay in which a close connection exists between the parts moving in the magnetic field and the microphonic contacts. To overcome this defect would be a great service to the art of telephony.

It is thought by some that this crepitation noise is analogous to that of the singing electric light arc; it can be started in any transmitter either by too strong a current or by a suitable reaction between the vibratory motions in the transmitter and the current in the telephone circuit of which the microphone is a part, for instance the roaring can be started by holding a telephone connected with the circuit directly in front of the transmitter.

With the view of accomplishing two results, I have constructed the following form of telephonic relay. These results to be attained are as follows: First, the prevention of the reaction of the magnetic parts on the crepitation of the microphone to obviate the excessive roaring or "growling"; secondly, to provide means for a separate adjustment of the magnetic moving parts and the transmitter. This separate adjustment is evidently highly desirable; for the part moving in the magnetic field may be in a suitable position for the greatest sensitiveness, while the microphonic contact has not a suitable contact pressure; and any disturbance of adjustment of one of these parts of the apparatus disturbs the other. In accomplishing these results, the fact came out with great clearness that the separation of the microphonic contact by means of an air

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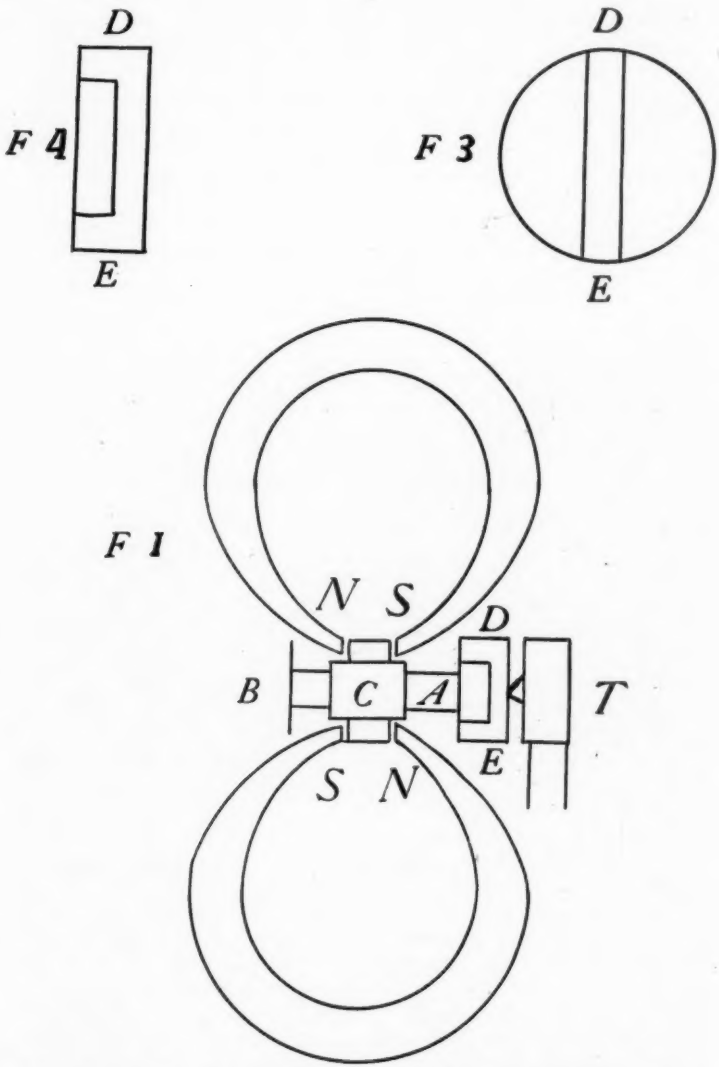

chamber from the magnetically moving parts, a separation claimed by many inventors, is inoperative unless there is a better sound-conducting medium between the microphonic contact and the vibrating part in the magnetic field than the

layer of air. In fact, the layer of separating air is incapable of transmitting the feeble vibrations of a telephone diaphragm sufficiently for relaying; while a suitable solid sound-transmitting support to the microphone in contact with the edges of a diaphragm actuated by the movements in the magnetic field transmits such vibrations very efficiently. This is an exemplification of the fact that a person partially deaf can hear if the vibrations are conveyed to the ear by contact with the supports of the ear.

Considering thus the principles involved in the construction of a practicable telephonic relay, I have invented the relay

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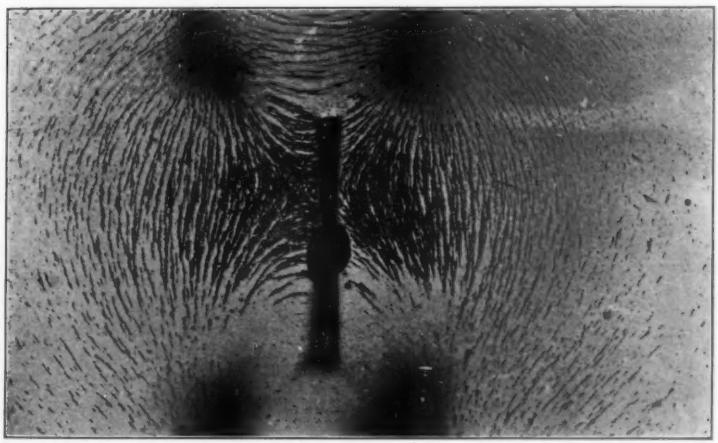

described below; a relay in which the barrier of undesirable "growling or roaring" is obviated; and a relay which permits of the desirable separate adjustment of magnetic parts and microphonic parts.

The relay consists of a small coil with a laminated iron core, which is balanced by two small diaphragms in a balanced magnetic field: the telephonic currents to be repeated or relayed enter the little coil and disturb the magnetic balance in the magnetic field.

In fig. 1, NS (diagrammatic) represent the poles of the magnetic field, C the moving coil actuated by the telephonic currents to be relayed, A and B the supporting diaphragms, DE sound-communicating support of the microphonic contacts or transmitter. This can be a heavy disc: in some experiments I have used a brass disc one half an inch thick and

have relayed loud and articulate speech. The main features of this relay are these: the magnetic field acts both in the direction towards B as well as toward A.

Fig. 2 shows by the lines of magnetic filings the character of this magnetic field. This arrangement may be considered a modification of the principle of the siphon recorder of Lord Kelvin, in which a to and fro thrust or vibration takes the place of the rotating or turning effect of feeble currents actuating a small coil suspended in a strong magnetic field.

The second important principle is the freedom of the central portion of the diaphragm A from the pressure of the transmitter T. The third point is the transmission of the vibrations of this diaphragm A by means of the sound-transmitting support of the transmitter to the transmitter T. As I have already said, the air enclosed in the chamber DE plays a very small part in the transmission of the vibrations of the diaphragm A. A proof of this important fact is as follows.

Fig. 3 represents a front view of the support DE of the transmitter, which in this case consisted merely of a metallic bar. Fig. 4 is a side view of this case. Here the air space between the transmitter and the diaphragm A is not enclosed, being open on both sides of the bar, which is connected at its edges with the diaphragm A. The transmission of speech in this case is loud, while if the connection at D and E with the diaphragm are removed and the bar upon which the transmitter rests in the same position parallel to the diaphragm A, a very feeble sound is transmitted through the intervening air.

One can, therefore, adjust the transmitter without bringing a pressure upon the most sensitive portion of the diaphragm A, its center, and without disturbing the adjustment of the moving coil C. The relay is very sensitive; it is loud, and the articulation good. Moreover it is free from the objectionable growling or enhancing effect of the crepitation of the microphonic contacts on the vibrations of the magnetic portion of the relay. I have been much indebted to the suggestiveness and mechanical skill of the mechanician of the laboratory, Mr. George W. Thompson.

The engineering problems connected with loading telephone lines are most interesting, and when completely solved may obviate the use of relays, and telephonic engineering may go through a phase analogous to that of the Morse telegraph, in which as I have said the telegraphic relay is subordinate in importance to good conducting lines. Nevertheless we have not reached this point yet, and the cost of a relay is practically nothing in comparison with the enormous expense of a loaded line. The relay, described in this article, seems to me to be an important solution of the problem of the telephonic relay.

Jefferson Physical Laboratory,
Harvard University.

Art. XXX.—*A Stony Meteorite from Coon Butte, Arizona;* by J. W. Mallet, University of Virginia.

I was told of the existence of the aërolite described in this paper by Mr. D. Moreau Barringer of Philadelphia, who found and owns the specimen, and has permitted me to examine and describe it.

Mr. Barringer and Mr. Benjamin C. Tilghman, members of the Academy of Natural Sciences of Philadelphia, have for some time been engaged in exploration at the locality known as Coon Butte in Coconino County, Arizona, whence large quantities of meteoric iron—commonly called Canyon Diablo iron—have been brought, and these gentlemen have recently sent a paper to the Philadelphia Academy on the subject of this exploration and their conclusions from the results they have thus far reached.

Mr. Barringer has sent me the following account of the circumstances under which he himself found the meteorite I have examined:

"On June 24th, 1905, while riding with Mr. S. J. Holsinger in a general northwest direction from the crater to our reservoirs in Canyon Diablo gorge, my attention was attracted by a rather curiously shaped stone lying on the surface of the thin soil which covers the level limestone plain extending for many miles in every direction in this region. The rather sharply pointed protuberance was what particularly attracted my observation and made me realize that it could not be a water-worn bowlder such as are frequently found in this region." "Upon getting off from our horses and examining the stone I at once suspected that it might prove to be an aërolite, and of course became much interested in the discovery. The greater portion of it was exposed to view, it being imbedded in the loose soil only to about an inch in depth. Two of the broken corners, as I remember, were exposed to view, and the fractures exhibited seemed to be quite fresh. I infer that these corners were broken off at the time of the fall. The locality at which it was found is typical of the region, namely a nearly bare or naked plain covered by loose soil and dotted here and there with bunches of sage brush, grease wood, etc. As I remember, the exact spot at which the stone was discovered is between a mile and a mile and a half distant from the crater in a general western direction, and about ten and a half miles in a southeast direction from Canyon Diablo station." "We made a thorough search for the fragments which had been broken off from this stone, but failed to find them. I infer that the stone struck the earth at some distance from the spot where it was found, and

rebounded to this spot by reason of the force with which it struck."

Mr. Barringer thinks it highly probable that this aërolite was *seen* to fall about a year and a half before he found it, and has sent me the following statement of facts in support of this opinion.

"About the middle of January, 1904—on the 15th of the month, as nearly as the date can now be fixed—while two of our employees at Coon Butte were watching the camp (we had suspended operations during the winter), they were awakened, so they told us, by a loud hissing noise and looking northward saw that the heavens were brilliantly lighted, and while rushing out of their tent saw a meteor fall somewhere west or northwest of the butte between them and the railroad. We paid no special attention to the story, and supposed that although they might have seen a meteor fall, it had come to the earth, if it came to the earth at all, many miles distant. However on the same evening and at the same moment, a few minutes before nine o'clock, the hour being fixed by the train schedule, Dr. A. Rounsville and Dr. G. F. Manning were travelling together from Williams, Arizona, to Canyon Diablo station, Dr. Rounsville sitting next to the window on the south side of the car, and just before the train stopped they saw a brilliant light outside of the train, which Dr. Rounsville described just as our men did—i. e. as being lighter than daylight. He could see the mountains twenty miles away, and distinctly every shrub and rock for hundreds of yards from the train. As he exclaimed to Dr. Manning, who occupied the same seat, concerning this light, he caught a glimpse of a fireball dropping to the horizon in the direction of Coon Butte. The light and the fireball were both seen by Dr. Manning also. It seems from the coincidence of time almost certain that this was the same meteor as that seen by our employees at Coon Butte, the observers being about twelve miles apart. It was very near a spot at the intersection of the two lines of sight, the direction of which they of course could not determine with exactness, that I found the stony meteorite."*

The specimen as received by me was pyriform, with a roughly triangular cross-section, bounded by two approximately flat surfaces (one larger than the other) inclined at about 60° or 65° to each other and united by a third, irregularly curved convex surface. It was a good deal larger at one end than at the other. The general surface was smooth, but indented at places with the characteristic shallow pittings, like thumb prints on a lump of sculptor's modelling clay, which

*Further correspondence, sent me by Mr. Barringer, shows that there is some doubt as to the date, but the preponderance of evidence is in favor of its having been *the same* in respect to both sets of observers.

are seen on so many meteorites. One, presumably rather large, piece had been broken off from the smaller end, and two other, much smaller, fractures appeared at and near the larger, end. Measuring the mass as it lay on the larger approximately flat face, the maximum length was about 14·5^{cm}, maximum width about 11·8^{cm} and maximum thickness about 8·9^{cm}. Fig. 1 is a reproduction of a photograph showing the general appearance. The weight of the specimen as it reached

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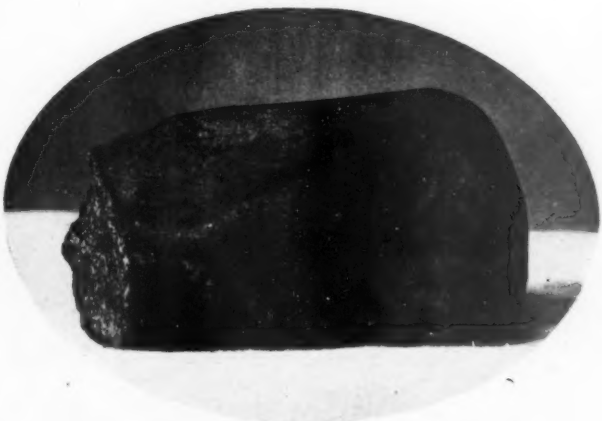

me was 2789 grams. There is an external oxidized crust, generally of dark, blackish brown color, with patches of redder brown—for the most part very thin, not exceeding ·5^{mm} in thickness; at some points the oxidized material runs in to a depth of 7 or 8^{mm}. A surface of fracture shows a gray mass of (not very well defined) chondritic and brecciated structure, with numerous little spots of iron-stained yellowish brown color, including lustrous points of metallic iron—the general appearance like that of the Pultusk meteorites of Jan. 30, 1868 (but without the glossy black crust of these stones). There is a still closer resemblance, both of crust and fractured surface, to the meteorites from Ness Co., Kansas. From the general appearance of the surface of fracture I am inclined to class this specimen as Brezina's breccialike gray chondrite, Cgb. The specific gravity of the whole mass taken by suspension in water at 15° C. was found to be 3·471, which is sensibly less than the results of calculation from the constituent materials as found by analysis, indicating some lack of compactness in structure.

Dr. George P. Merrill, Head Curator of Geology at the U. S. National Museum, who has given much attention to the

petrographic study of meteorites, very kindly undertook to have thin sections made of some fragments I sent him, to examine these under the microscope, and to secure photo-micrographs of some of them. The notes with which he has favored me are as follows, and in figs. 2, 3 and 4 the accompanying photo-micrographs are reproduced.

2

Section showing structure. The black areas are nickel-iron and metallic sulphides; the light areas are olivine and enstatite.

"Aside from its metallic constituents, the stone consists mainly of enstatite and olivine. The enstatite, which is largely in excess, occurs in granular forms, without distinct crystal outlines and also in chondrules of the usual fan-shaped radiating and granular structures (figs. 2 and 4). In the larger forms of the single crystals a condition of molecular strain is manifested by the manner in which, between crossed nicols, the dark wave sweeps over the surface. Such a condition, it may be stated, is not uncommon in stony meteorites, through its full significance seems not to have been realized.

The olivine likewise occurs in granular form and in that of chondrules with the characteristic barred or grate-like and,

more rarely, porphyritic, structures. Except where stained by a recent oxidation of the ferruginous constituents, both minerals are colorless or but slightly gray.

In addition to the mineral above described is a completely colorless isotropic substance occurring, as a rule, with no crystal outlines, but rather filling interspaces as would an interstitial glass. It is sometimes quite free from enclosures or, again, includes numerous silicate granules and opaque metallic particles. Rarely does it show anything suggestive of cleavage

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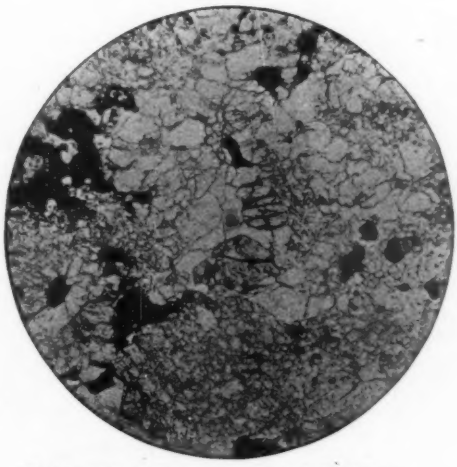

Section showing supposed maskelynite at *a*.

(see fig. 3 *a*). Excepting in its lack of crystallographic outlines, the mineral is similar in all respects, as far as appearance goes, to the maskelynite of the Shergotty (India) meteorite, and such I shall have to assume it to be. It is altogether too small in amount to permit a satisfactory chemical determination, though with more material a micro-chemical test might be made which would go a long way towards settling the problem.

The chondritic structure of the stone is not strongly marked, and the individual chondrules are themselves almost invariably of a fragmental nature. The one shown in fig. 4 is the most perfect exhibited in any of the slides. The structure, as a whole, is not unlike that of the Ness County, Kansas, stone, and hence, if we follow Brezina, would be placed in the group of intermediate chondrites, brecciated (Cib). As, however, I have examined this stone only in thin sections, none of which

include an area of above 10^{mm} square, it is possible that further study might relegate it to the Cgb group, of which the Pultusk stone is a well known representative.

For the photo-micrographic illustrations accompanying these notes I am indebted to the U. S. Geological Survey."

The chemical analysis was found to be somewhat troublesome, particularly in regard to the distribution of the iron present in several different chemical conditions. The greater part of the metallic nickel-iron, accompanied by some schrei-

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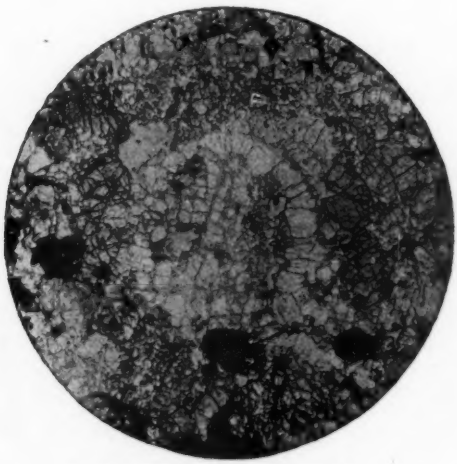


Section showing enstatite chondrule.

bersite and pyrrhotite, was separated from a pulverized sample of about fifty grams, free from crust, by means of a magnet, but it was not possible to obtain complete separation in this way, so that a small proportion of silicates had to be deducted from the magnetically separated part, and a small proportion of the constituents of the nickel-iron, schreibersite and pyrrhotite to be in like manner deducted from the siliceous part of the mass dissolved by acid. The part left by the magnet was digested with hydrochloric acid of 15 per cent strength for three days at a moderate heat, and thus a general separation of the decomposable from the undecomposable silicates was effected, but several determinations of particular constituents had to be made on individual portions. Hydrofluoric acid was used to obtain the alkalies, and the same reagent, with exclusion of air, to secure a determination of ferrous iron.

The following statement gives the general results reached, with an appended account of how they were obtained.

Enstatite	44·73
Olivine	33·48
Maskelynite (?)	6·87
Nickel-Iron	8·63
Iron rust	3·03
Schreibersite	·76
Pyrrhotite	2·14
Chromite	·08
	99·72

The minute amount of chromite was recovered from the silica of the portion undissolved by hydrochloric acid. There being but a few milligrams, no attempt was made at any analysis of it beyond fully establishing the presence of chromium.

Pyrrhotite was calculated from the amount of sulphur found, assuming the ratio S : Fe = 39 : 61. The sulphide was taken as pyrrhotite, rather than troilite, as the former is believed to occur more commonly in meteoric stones, the latter in meteoric iron. It may of course be troilite, and it may perhaps contain a little nickel.

Schreibersite was calculated from the amount of phosphorus found (partly in the magnetically separated portion, partly in the residue left by the magnet) on the assumption of the ratio, P : Fe : Ni = 15 : 56 : 29.

Iron rust was calculated from the amount of iron found in the ferric state and the amount of water driven off by heating and *collected*, assuming the composition to be that of most ordinary rust, namely, $Fe_2O_2(HO)_2$.

The nickel-iron was obtained by analysis of the magnetically collected portion, deducting mechanically adhering silicates and small amounts of sulphur and phosphorus found in this portion, and adding a small amount of nickel found in the portion left by the magnet (in excess of that accounted for as phosphide in schreibersite) and a quantity of iron from the same portion equivalent to the metallic copper thrown down from a solution of cupric sulphate.

The percentage composition of the nickel-iron, as thus obtained, is

Fe	88.81
Ni	10·72
Co	·15
Cu	trace
Sn	·01
Mn	trace
C	trace
	99·69

I was interested in again finding in iron of meteoric origin minute amounts of both copper and tin, having in former years identified both these metals as constituents of the Augusta Co., Va., and Wichita Co., Texas, meteoric irons. In the case of the Coon Butte meteoric stone none of the granules of nickel-iron exceeded ·5 or ·6^{mm} in diameter.

The feldspathic mineral supposed to be maskelynite was calculated from the alumina found, assuming (on the basis of Tschermak's analyses) that this forms 25 per cent of the mineral so named, assigning to this (on the same basis) silica in the ratio $Al_2O_3 : SiO_2 = 25 : 55$, and adding lime and the oxides of the alkaline metals as actually found. Lithium was tested for, but could not be detected. With these assumptions the percentage composition of the mineral in question is

SiO_2	55.00	assumed
Al_2O_3	25·00	assumed
CaO	14·17	
Na_2O	5·93	
K_2O	1·72	
	101 82	

As most of these constituents were found partly in the portion soluble and partly (to a larger extent) in that insoluble in hydrochloric acid, it is probable that the feldspathic mineral is attacked, though not readily, by that acid. But it is of course quite possible that some of these constituents may belong to the other silicates present. The supposition of Tschermak that maskelynite is simply a feldspar that has cooled from fusion in an amorphous state seems quite reasonable and likely.

Olivine was calculated from the remaining constituents of the portion left by the magnet and decomposed by hydrochloric acid, after deduction of the small quantities of iron, nickel and other minor constituents already disposed of as above, and also those of the maskelynite (?) to the extent indicated by the alumina, etc., found in this portion decomposed by hydrochloric acid. Thus calculated, the olivine gives the following percentage figures—

SiO_2	42·29
TiO_2	·01*
MgO	42·44
FeO	13·57
	98·31

* More exactly ·006.

This shows an excess of silica over that required for the orthosilicate of between 4 and 5 per cent, suggesting the possibility of a little free silica being present, perhaps as the asmanite (tridymite) of Maskelyne. That form of silica, it is stated, is soluble in a boiling solution of sodium carbonate in water, and as such a solution was used to take up the silica set free by the action of hydrochloric acid, it would be found and counted in with that of the olivine.

Enstatite was calculated from the results of analysis of the portion left by the magnet and not decomposed by hydrochloric acid, deducting the minute quantity of chromite and such of the constituents of the so-called maskelynite as occurred in this portion. The figures so obtained give the following percentage composition for the enstatite—

SiO_2	53·87
MgO	26·55
FeO	18·35
	98·77

showing a very fair accordance with the results of calculation from the formula of the mineral.

University of Virginia,
Feb. 3, 1906.

ART. XXXI.—*On a New Stony Meteorite from Modoc, Scott County, Kansas;* by GEORGE P. MERRILL, with analyses by WIRT TASSIN.

THE meteoric stone described below was received at the National Museum from Mr. J. K. Freed, to whom we are indebted for the facts given relative to its fall and the privilege of describing it.

The stone fell on the night of September 2, 1905, about 10 P. M., and seems to have come from the west or southwest. When about six miles due west of Scott City it exploded with what is described as a terrific roar, plainly heard for a distance of 25 miles, awakening those who had already gone to sleep and frightening people for miles around. Its appearance when exploding was variously described as like the "headlight of a locomotive," and a "white light as big as a haystack afire." Eighteen miles south of Scott City it is stated to have been light enough to "pick up a pin." Following the explosion, was a noise compared with the discharge of a heavy battery of artillery or of a heavy wagon running rapidly over the frozen ground, the noise gradually dying away like rolling thunder in the distance. Some claim to have heard the whistling of rocks through the air like bullets or heavy hail. Mr. Freed himself compares the sound to that of "a mighty swish-h-h, resembling the sound of a sky rocket."

After a search extending over a period of more than a year, fourteen pieces have been reported as found, scattered over an area some two miles by seven in the vicinity of Modoc, a small town on the Missouri Pacific Railroad. These were mostly complete individuals. Three and a fragment received at the National Museum weighed, respectively, 4640, 1170, 490, and 110 grams. Two others obtained by Dr. O. C. Farrington for the Field Columbian Museum are reported as weighing about 5400 grams. An individual of approximately 2000 grams weight is reported as in the hands of a collector in Kansas. This accounts for seven out of the fourteen reported finds. It seems safe to assume that the weight of the entire fall could not have been less than 15 kilograms.

The 4·64 kilo individual received at the Museum was the largest thus far reported. Its dimensions are: Height over all, 21^{cm}; maximum width, 15·5^{cm}; thickness, 10·65^{cm}. This was found several miles east of the others and was imbedded but four or five inches in the hard buffalo grass sod, inclining slightly to the west. It is a complete individual, with the exception of a small fragment of about an ounce weight, which

had been broken away to send to the Museum previously for examination.

This and the others examined are covered with a dull brown-black, slightly rough crust of approximately a millimeter in thickness, showing no traces of flow structure nor perceptible thickening in any part such as would indicate the position of the block in its flight through the air. The surfaces are, on the whole, rather free from pittings. Sundry darker streaks running parallel with the broader faces suggest a lack of homogeneity or a possible fissuring of the mass.

The broken surface shows the stone to be very indistinctly chondritic and of a color even lighter gray than the Möcs or Drake Creek, Tennessee stone, which it closely resembles. With a pocket lens abundant metallic points are visible.

Under the microscope the stone is found to consist essentially of olivine and enstatite in characteristic jumbled, granular crystalline forms, interspersed with larger irregular granules and indistinctly outlined chondrules of the same material, together with blebs of metallic iron and troilite. As already noted, the chondritic structure is quite inconspicuous on a broken surface, the individual chondrules consisting of irregularly rounded, oval and sometimes angular aggregates of olivines in granular and grate-like forms, or enstatites in eccentric radiating masses, in either instance the interstices being often occupied by a colorless mineral identified as feldspar. In a single instance a chondrule was noted consisting of a coal-black dust-like material interspersed with a few blebs of troilite, the whole being nearly surrounded by the colorless zone of feldspar (?), the appearance in an ordinary light being practically identical with the black chondrule from the meteorite of Chateau Renard, as figured by Tschermak.* The mineral identified as a plagioclase feldspar occurs in small, perfectly clear and colorless interstitial forms, so lacking in crystalline outline and cleavage as at first to suggest a residual glass. Extinction angles are quite unsatisfactory, the dark waves sweeping across the face of the crystals in a manner indicative of a condition of strain; and, were it not for an occasional particle with inconspicuous twin bands, the real nature of the mineral would be in doubt. It was, unquestionably, the last mineral to crystallize, is quite free from enclosures, and occupies the interstices of the olivines and enstatites, often partially enwrapping them, very like a glass, but between crossed nicols polarizing faintly in light and dark colors and breaking up into granular masses comparable with the secondary feldspars in the drusy cavities of metamorphic rocks. Aside from occurring between the bars and radiating columns of the chondrules, as already mentioned, it is scat-

* Die mikroskopische Beschaffenheit der Meteoriten, pl. 17, fig. 3.

tered throughout the ground in a manner closely identical with that of the Milena meteorite, as also figured by Tschermak.*

As noted above, the stone is traversed by fine, thread-like black veins, though how abundant such may be it is impossible to tell without breaking the specimen, and this the writer has not been able to obtain permission to do.

The fall adds one more—the twelfth—to the remarkable list for which Kansas has become noted.†

As will be seen from the description, the stone belongs to Brezina's group of veined chondritic meteorites (Cwa). It will be known as the Modoc, Scott County, meteorite.

Chemical analysis, by Wirt Tassin.

The native metal was determined in 2·0255 grams of the crust-free meteorite as follows: The finely pulverized material was treated in the cold with a solution of mercuric ammonium chloride, in an atmosphere of hydrogen. The results were:

Fe	6·56
Ni	0·68
Co	0·034

The sulphur was determined in 1·0300 grams of the meteorite, after fusion with $Na_2CO_3+KNO_3$. This yielded:

S	1·38

The phosphorus was estimated in 1·0450 grams, and the percentage found was:

P	0·051

The soluble silicates were determined by treatment with HCl, sp. 1·06. The action was allowed to take place on the water-bath and continued but two hours. The acid then decanted off and the operation twice repeated. This treatment gave:

SiO_2	17·38
FeO	10·95
Al_2O_3	0·20
CaO	0·14
MgO	17·73

The insoluble silicates were determined after fusion with Na_2CO_3. The alkalies were necessarily determined in a separate portion. Chromite was not present:

* Die mikroskopische Beschaffenheit der Meteoriten, pl. 16, fig. 3.

† For an enumeration of these see "A Newly Found Meteorite from Admire, Lyon County, Kansas," Proc. U. S. National Museum, vol. xxiv, 1902, pp. 907–913.

SiO_2	26·75
FeO	4·42
MnO	0·10 (?)
Al_2O_3	2·27
CaO	1·60
MgO	8·72
K_2O	present but not determinable
Na_2O	0·44

The general composition of the portions of the meteorite analyzed, as derived from the combination of the several determinations, is:

Fe	6·56
Ni	0·68
Co	0·034
S	1·38
P	0·051
SiO_2	44·13
FeO	15·37
MnO	0·10 (?)
CaO	1·74
MgO	26·45
Al_2O_3	2·47
K_2O	trace
Na_2O	0·44
	99·40

The mineralogical composition of the meteorite may be approximately calculated from the above summation. The amount of nickel-iron is determined directly; troilite and schreibersite are calculated from the amounts of sulphur and phosphorus found, assuming that schreibersite has the formula Fe_3NiP. The soluble silicate is olivine. The insoluble silicates are regarded as enstatite and the feldspathic mineral noted, the amount of alumina found furnishing the basis for the calculation:

Nickel iron	4·59
Troilite	3·79
Schreibersite	0·34
Olivine	46·40
Enstatite	29·94
Other insoluble silicates	14·36
	99·42

It must be confessed that the last item in the calculation is not wholly satisfactory, the 14·36 per cent of other insoluble silicates not being accounted for in the microscopic examination. It undoubtedly includes the feldspathic constituent and

presumably also a portion of the irresolvable matter of the chondrules. A like condition of affairs was noted by Borgström in his description of the Shelburne meteorite,* which, from a chemical standpoint, this closely resembles.

The specific gravity of the Modoc stone was determined on two complete individuals, weighing 1110 and 490 grams, respectively, by a large apparatus constructed on the plan of the beam balance recommended by Penfield in the latest edition of his Brush Determinative Mineralogy. No attempt was made to exhaust the air from the pores, the stone being immersed in water and, with frequent agitations, allowed to remain until no more bubbles were given off. The average of two determinations was 3·54.

Addenda.

Together with the samples of Modoc meteorite forwarded, Mr. Freed included two small pebble-like masses, which had been found by his boy and which it was thought might possibly be also of meteoric origin. One of these was of ferruginous quartzite. The other, some 40 by 60 millimeters in greatest diameter, and weighing 135 grams, proved to be meteoric. This, although weathered to a dull rusty brown on the surface, still showed distinctly the usual pittings, and on a polished surface presented a dull dark-gray ground thickly spotted with small points of metallic iron and occasional rounded areas recognized with the unaided eye as chondrules. Under the microscope this is found to consist of an extremely fine tufaceous ground carrying large clear olivines in single crystals and scattered aggregates and numerous chondrules of both olivine and enstatite. The olivine chondrules are in part polysomatic and in part of the common barred or grate-like character. The enstatite chondrules are most commonly in radiate forms. The entire structure and even the identity of some of the mineral constituents are much obscured by iron oxides which have stained the mass an ocherous red throughout. The metallic constituents are much more abundant than in the Modoc stone named above.

Although differing somewhat from Washington's description and my own studies on the meteorite of Jerome in the adjoining county of Gove, the differences are so slight as to be seemingly non-essential, and I am inclined to regard this as a straggler from the Jerome fall, which, it will be remembered, was found on April 10, 1894, on the Smoky Hill River and has been described in detail by Dr. Washington, in this Journal for June, 1898, vol. v, p. 447. There is, however, a chance for a difference of opinion on this subject.

* Trans. Royal Soc. of Canada, 1904.

ART. XXXII.—*The Determination of the Feldspars by Means of their Refractive Indices;* by FRED. EUGENE WRIGHT.

OF the many methods which have been suggested for the discrimination of the feldspars, perhaps none has received less actual attention from petrologists than those based on the refractive indices, notwithstanding the fact that the refractive power of a mineral is one of its fundamental properties and can be determined approximately with comparative ease. The application of the refractive index methods to the feldspars was tested in detail by F. Wallérant,* who determined their refractive indices directly on a total refractometer attachment to his microscope. His particular method is applicable to all minerals except those of the highest refracting power, and would be in general use at the present time were it not for the special apparatus demanded and the fact that thin sections for his purposes require special preparation.

The method which is described below has proved serviceable in actual practice, and is based on the ability to determine the average refractive indices of the feldspars under the microscope by applying the principles developed by Schroeder van der Kolk some years ago.† The conception of the method is therefore not novel, and the following paragraphs are intended solely to suggest a modus operandi which has been found convenient.

Small mineral fragments when observed in obliquely incident light show, on immersion in liquids of higher or lower or equal refractive index, characteristic phenomena which are extremely sensitive and can well be used to distinguish minerals whose average refractive indices vary only five points in the third decimal place. As the theory of these phenomena, however, is given in full in the papers cited, only the practical application of the method to the study of the feldspars will be considered below.

Equipment.—Seven liquids are required whose refractive indices for yellow light are equal respectively to the refractive indices β for

Orthoclase	(Or)	1·523
Albite	($Ab_{12}An_1$)	1·536
Oligoclase	(Ab_3An_1)	1·545
Andesine	(Ab_3An_2)	1·554
Labradorite	(Ab_3An_3)	1·563
Bytownite	(Ab_1An_3)	1·572
Anorthite	(Ab_1An_{12})	1·582

* Bull. Soc. Min. Fr., pp. 268–271, 1898.

† Tabellen zur mikroskopischen Bestimmung der Mineralien nach ihrem Brechungsindex. Wiesbaden, 1900. Compare also Rosenbusch-Wülfing, Mikroskopische Physiographie, 1904, I, 1, 259–261, also II, 345; and Fred. E. Wright, Tschermak Miner. Petr. Mittheil., xx, 239, 1901 and this Journal, xvii, 385–387, 1904.

and can be prepared by mixing oil of cedar (n_{na}=1·516) and clove oil (n_{na}=1·532) for orthoclase and albite; and clove oil (n_{na}=1·532) with cinnamon oil (n_{na}=1·601) in the requisite proportions for the remaining members. These liquids are miscible in all proportions, evaporate at nearly equal rates and are well adapted for the method. They can be kept in small glass stoppered dropping bottles, mounted on a square wooden block and labelled with the name of the feldspar to which their refractive index corresponds, Another series consisting of monochlorated benzene (1·523), oil of cloves (1·532), aethylene bromide (1·544), nitrobenzene (1·554), mono-bromated benzene (1·562), and mixtures of the latter with bromoform (1·595), has been found to give equally good results, but cannot be procured so readily. Dilute Thoulet solutions might also be employed, but are not to be recommended since a slight evaporation of the water changes their refractive index rapidly. The solutions can be standardized either by measuring their refractive indices directly on a refractometer or by using fragments of typical feldspars as test objects in the method described below.

Manipulation.—In the actual determination of the feldspar, small grains of the substance 0·1 to 0·001^{mm} in diameter are used and can readily be obtained by breaking up, in an agate mortar, larger fragments of the mineral which have been chipped off the hand specimen. After immersion in a drop of one of the liquids between object glass and cover slip, the grains are observed in obliquely incident light under a microscope fitted with a medium power objective and condenser lens slightly lowered.* The nicols should not be crossed. The simplest way to produce oblique rays of light is to cast a shadow on part of the microscopic field by placing the forefinger between the reflector and lower nicol tube on the microscope. In place of the finger a piece of cardboard or a movable iris or stop diagram can be substituted to advantage.†

* In actual practice, it will be found that the phenomena on which this method depends can be reversed by raising or lowering the condenser lens. If a medium power objective be used, and the condenser lens be raised from its lowest possible position to direct contact with the object glass, it will be noted that the edge of the shadow, cast over part of the field, becomes more distinct on elevation, until at a certain point it is in sharp focus, after which it again becomes less clearly marked. It is in the lower and higher positions of the condenser lens and within the transition zone of the indistinct edge of the shadow that the phenomena are most clearly defined. On passing the focus point, we pass from divergent to convergent rays and the phenomena, which appear, are reversed. In the description below the condenser lens is considered to be in its lower position below the point of sharp focus. As a check on the observations, it is often advisable to raise the condenser lens and observe the reversed phenomena. By placing the condenser lens in suitable position, the highest power objectives can be used equally well and minute particles thus be studied.

† Compare Tscherm. Min. Petr. Mittheil., xx, 238–239.

By shading half the microscopic field in this manner, the edges of the small grains on the object glass will appear to be unequally lighted near the dark shadow. If the mineral grain be more highly refracting than the liquid, its edge next the shadow will appear brighter than the edge opposite; on the other hand, if the liquid have higher refracting power, the phenomena are reversed and the light band appears on the farther side from the shadow, while the adjacent edge appears darker than the rest of the grain. In case both mineral and liquid have equal refractive indices for light waves of medium length, the opposite edges of the mineral grain appear brilliantly colored—bright red on one side and blue along the farther side. The occurrence of the red and blue bands along opposite edges of the mineral is, therefore, a sufficient criterion that the refractive indices of mineral and liquid are equal for light waves of medium length. The dispersive power of liquids is often strong, and care should be taken that the colors which appear are actually red and blue and that both edges of the grain are equally bright.

By trial, the approximate refractive index of the feldspar fragment is thus found and the variety determined.

Since in this method cleavage fragments alone are used, extinction angles on (001) P and (010) M can be measured in the same powder preparation and a still more accurate determination made. The determination of the refractive index, moreover, relieves the ambiguity which exists in the angles obtained from certain members of the feldspar series.

In practice, this method has proved particularly valuable in the study of rocks containing both plagioclase and orthoclase. In the thin section it is not always a simple matter to recognize small amounts of orthoclase when abundant acid plagioclase is present, while by the refractive index method the two can be distinguished readily and accurately. Similar conditions obtain in specimens containing both orthoclase and nephelite, in which case the method applies to equal advantage.

Geophysical Laboratory, Carnegie Institute, Washington, D. C.

Art. XXXIII.—*Siderite and Barite from Maryland;* by Waldemar T. Schaller.*

Siderite.

A number of specimens of small splendent crystals of siderite were obtained through the courtesy of the Foote Mineral Company of Philadelphia, who give as the locality, "within two miles of Frostburg, Maryland." The crystals are very small and are deposited in great numbers on a gray massive siderite rock. A very striking feature of the crystals of siderite is the splendent play of colors that they show. They are very iridescent, and while their color is brown, the light reflected from the surfaces of the crystals is in all colors. Associated with the siderites and intermingled with them are numerous small barite crystals. The matrix is a compact impure iron carbonate having a specific gravity of 3·7. In this are imbedded occasional masses of white, opaque barite showing good cleavage. In the rock are numerous cavities which are lined with siderite and barite crystals, the specimens forming geodes, the crystals having been derived from the massive rock.

The crystals vary in size from those which are very minute to those a millimeter in size. They are mostly attached to the matrix by one end, though double terminated crystals are by no means rare, these being irregularly scattered through the mass. The entire layer of crystals is about a millimeter thick.

Chemical Properties.—A number of the crystals were broken from the specimens and very carefully selected from the matrix by hand. The crystals were freed from a small amount of barite by the electromagnet and finally about one-tenth of a gram of pure crystals was obtained, of which each crystal had been picked out and shown to be free from any foreign matter. It was noted that the crystals did not possess a uniform color, some of them being a much lighter brown than others. It was at first thought that the lighter colored ones contained calcium or magnesium, but such was found not to be the case. The change in the intensity of the brown color of the crystals cannot be solely due to the amount of iron in the crystals. The selected crystals were dissolved in hydrochloric acid and the iron precipitated with ammonia and weighed. Tests made for maganese, calcium and magnesium showed them to be absent. The weighed iron oxide was fused with sodium bisulphate, reduced and titrated with potassium permanganate, giving practically the same figure.

* Published by permission of the Director of the U. S. Geol. Survey.

FeO	62·01 (calc.—62·07% FeO)
MnO	none
CaO	none
MgO	none

The crystals are therefore pure iron carbonate and well suited for obtaining crystallographic constants for siderite.

Crystallographic Properties.—The siderite crystals have a rather unusual habit for that mineral, as the dominant form is the scalenohedron $v=\{21\bar{3}1\}$, the common form for calcite. A number of other forms are present, and a very marked feature of these crystals is that in approximately the places where the *a*-face would come there are rounded hollows. The crystals are highly polished and seemed likely to give perfect reflections, but on examination on the two-circle goniometer, it was found that the faces were not as perfect as was at first expected. This is due chiefly to the fact that some of the large scalenohedral faces appear broken and the parts slightly displaced, yielding more than one signal, several minutes apart. The crystals were mounted in polar position, and so adjusted that on turning the vertical circle (the horizontal one being clamped) the reflections from the several faces of each form fell, respectively, in a vertical line coinciding with the vertical cross hair. After the crystal was adjusted as perfectly as possible, the reading on the horizontal circle was taken for each face, the signal being brought to the exact center of the field in each case. The forms present are shown in the following table, those forms which are new for siderite being marked with an asterisk.

r	$10\bar{1}1$
**l*	$70\bar{7}5$
**k*	$50\bar{5}2$
f	$02\bar{2}1$
v	$21\bar{3}1$
**y*	$32\bar{5}1$

The new form $l=\{70\bar{7}5\}$ occurs but once as a small face below $\{10\bar{1}1\}$ but larger than that face. The reflection was fair.

	ϕ	ρ
meas.	0° 14′	52° 49′
calc.*	0° 00′	53° 07′

The form $k=\{50\bar{5}2\}$ occurs as a minute line face somewhat rounded, and truncating the edges of the scalenohedron $v=\{21\bar{3}1\}$. The measurements show that the ρ angle is about 68°, though no accurate measurement could be obtained.

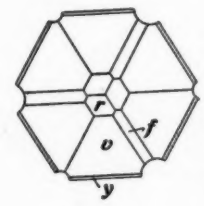
calc. (ρ) = 67° 12′

* From element derived by writer.

The unit rhombohedron r occurs on nearly all of the crystals as small faces truncating the apex of the crystals. The new scalenohedron $y = \{32\bar{5}1\}$ occurs on all the crystals and is a characteristic form for this locality. Though it varies in size, becoming relatively wide and short or narrow and long, its general form is shown in figure 1.

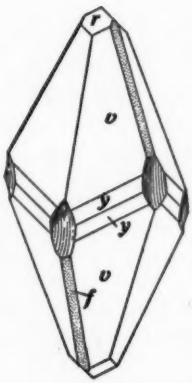
The zone $v\ y\ y^{VI}v^{VI}$ is sometimes somewhat striated between y and y^{VI}, and using the dot signal, it was seen that there was a maximum of brightness in the position required for the faces $\{7.6.\bar{1}3.1\}$ and $\{11\bar{2}0\}$. It could not be shown, however, that these faces were actually present.

1



The form $f = \{02\bar{2}1\}$ occurs as broad dull faces giving no reflection and only an almost imperceptible haze of light. Measurements of the ρ-angle gave values from 59° to 62°, calc. 62° 17′.

The concavities give an indefinite blaze of light in the zone of the negative rhombohedrons, about 80° from the base, so that they do not reach down to the prism zone. A study of these hollows on the goniometer, using the dot signal, showed that they consisted of vertical striations approximating in the center of the form $\{06\bar{6}1\}$, and at the extreme edge to $\{11\bar{2}0\}$, with many forms in between these.

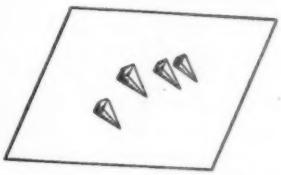


Siderite.

Fig. 1 is an attempt to illustrate the actual appearance of these crystals, showing, particularly, the concavities described. The indentations in the orthographic projection are somewhat exaggerated. With the exception of these and the broad dull faces of $\{02\bar{2}1\}$, the faces of the crystals are highly polished, and do not show any etching. It seems probable that these hollows should be regarded as the result of an incomplete or skeletal growth rather than as the result of etching. They are, in a way, analogous to the hopper-shaped crystals of sodium chloride, where the two faces 001 and 100 (in one zone) alternate and the resultant hollow has, in cross section, a V-shape. In the case of the siderites, however, instead of an alternation of the two faces, $06\bar{6}1$ and $11\bar{2}0$, there is a gradation from the prism to the rhombohedron and the result is a rounded hollow instead of a sharply angular one, as in the case of sodium chloride.

Etch Figures.—A cleavage piece was left standing in cold dilute hydrochloric acid for several days and then examined under the microscope, when well-defined etch figures could be observed. These are triangular in shape and possess a plane of symmetry parallel with the shorter diagonal of the cleavage rhomb of siderite, and are shown in figure 2. They resemble in symmetry the figures shown in Miers' Mineralogy (page 112) for calcite and not those given for dolomite. The symmetry of siderite is, therefore, the same as that of calcite and not that of dolomite, a conclusion sustained by the forms of the crystals.

2



Etch figures on cleavage surface of siderite.

Value for c-axis.—Although siderite is a common mineral, good crystals are rare and the literature on siderite is poor in crystallographic data. The only value for the axial ratio given and which is adopted in all books is one obtained in 1812 by Wollaston. His statement in regard to siderite is as follows:* "I have examined various specimens of this substance, some pure white, others brown, some transparent, others opake. That which gives the most distinct image by reflection is of a brownish hue, with the semi-transparency of horn. It was obtained from a tin mine, called Maudlin Mine, near Lostwithiel in Cornwall. By repeated measurements of small fragments of this specimen, the angle appears to be so nearly 107°, that I cannot form any judgment whether in perfect crystals it will prove to be greater or less than that angle.

In this instance the carbonate of iron is nearly pure, and so perfectly free from carbonate of lime . . . . . "

The measurements of the faces giving good reflections were used for calculating a value for the *c*-axis. The angles for the same form varied somewhat on different crystals, though the values obtained from the measurements of different forms agree very well with each other. From the average reading, the following values were calculated:

From	10	meas. of	$r = \{10\bar{1}1\}$,	$c = \cdot 82352$
"	27	" "	$v = \{21\bar{3}1\}$,	$c = \cdot 82463$
"	16	" "	$y = \{32\bar{5}1\}$,	$c = \cdot 82311$
			Average,	$c = \cdot 8240$

An attempt was made to measure the cleavage angle directly, but it was found that the resultant cleavage faces were never

* Phil. Trans., 159, 1812.

perfectly plane, with the result that each face gave several signals.

After this value for c was obtained and found to be different from the commonly accepted value, 10 more crystals were measured and after the greatest care in so adjusting each crystal that the reflections from the scalenohedral faces of v fell as nearly as possible in a straight line, each reflection was carefully measured. In the case of more than one signal, the extremes were measured and the average taken. The average value for the ρ angle for each crystal (six faces) is :

68° 14′	21′
26	27
18	20
15	19
16	29

Av. $68°20\frac{1}{2}'$, $\therefore c = \cdot 8243$

The values for the two extremes, 68° 14′ and 68° 29′, are :

$$c = \cdot 8197 \text{ and } c = \cdot 8302$$

Taking the average of the values found from r, v, y, namely, ·8240, and that found from the 10 crystals, namely, ·8243, we get as a value for the c-axis for siderite of known purity,

$$c = \cdot 8241$$

As however, this value differs considerably from that adopted for siderite and as the crystal faces were at times uneven and the angular measurements showed considerable variation, the writer is rather hesitant in urging this new value. It, at least, serves to throw some question over the commonly accepted value and shows the need of additional measurement of material shown by chemical analysis to be pure.

The complete lists of forms so far observed on siderite is as follows :

$c = 0001$	$k\dagger = 50\bar{5}2$	$d = 08\bar{8}1$
$m = 10\bar{1}0$	$M = 40\bar{4}1$	$\delta = 44\bar{8}6$
$a = 11\bar{2}0$	$e = 01\bar{1}2$	$\alpha = 44\bar{8}3$
$g^* = 10\bar{1}2$	$h^* = 03\bar{3}2$	$v = 21\bar{3}1$
$z^* = 30\bar{3}4$	$f = 02\bar{2}1$	$\beta = 24\bar{6}1$
$r = 10\bar{1}1$	$\omega = 07\bar{7}3$	$y\dagger = 32\bar{5}1$
$l\dagger = 70\bar{7}5$	$s = 05\bar{5}1$	$i\ddagger = 41\bar{5}9$

Those with no reference mark are found in Dana's Mineralogy.

* Gonnard, Bull. Soc. Min., xviii, 382, 1895 ; also 1st supplement, Dana.
† The present paper.
‡ Cesàro, Ann. Soc. G. Belg., xviii, 1891 ; also 1st supplement Dana.

Barite.

The barite occurs in three different forms on the specimens seen by the writer. The first is the white massive form which is often imbedded in the matrix. It is usually opaque and shows good cleavage. The second form occurs as an opaque white efflorescence which is composed of an aggregate of minute crystals. The third form is present in transparent colorless crystals which often reach a length of several millimeters, though usually they are rather smaller. The largest ones seen were about a centimeter long and 1 to 2^{mm} thick. On some specimens these transparent crystals are attached by one end to the massive barite and form a fringe, as it were, around it, the crystals standing normal. This occurrence is very suggestive of a secondary formation of the crystals, they being derived from the massive barite in the matrix. The large clear crystals are probably a more perfect development than the white efflorescence and both are doubtless derived from the massive barite. In the massive barite there are no siderite crystals, though small fragments of the matrix are included therein, and in the efflorescence there are frequently found enclosed crystals of siderite, and the clear large barite crystals are intermingled with those of siderite.

The crystals of barite are of especial interest as they are of an uncommon habit; they are prismatic, elongated parallel to the vertical axis. Such crystals have been noticed several times but are not the common form for barite.

The faces of the crystals are highly polished and gave excellent signals. The prism zone is occasionally striated, especially the macropinacoid, though for the most part the zone is not striated and each face is distinct and plane. The forms present are:

$c = 001$	$m = 110$	$q = 114$
$b = 010$	$\eta = 320$	$f = 113$
$a = 100$	$\lambda = 210$	$r = 112$
$\chi = 130$	$o = 011$	$R = 223$
$B = 370$	$d = 102$	$z = 111$
$n = 120$	$l = 104$	$*N = 551$
$N = 230$	$v = 115$	$y = 122$

The prism $B = \{370\}$ occurs twice on two crystals as small faces, usually giving a fair reflection. The angles measured are as follows:

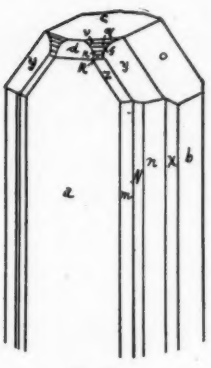
28° 09′, 27° 52′, 27° 45′, 27° 41′ calc. 27° 45′

The form was first noted by Düsing* and classed as doubtful by Dana and is not included in Goldschmidt's Winkeltabellen.

* Zeitschr. f. Kryst. xiv, 481, 1888.

The pyramid $N = \{551\}$ is new for barite,
meas. (ρ), 84° 55′, 84° 58′, 84° 08,′ 84° 45′ calc. (ρ) 84° 45′
It occurs as very small faces.

3



Barite.

The general ideal view of these crystals is shown in figure 3, though in detail the size of the various forms varies considerably even on the same crystal. There are, also, unusually more faces (line faces) in the prism zone than are shown in the figure. Occasionally the crystals are flat, parallel to the macropinacoid, but they are usually of equal diameter, horizontally. At times, too, one side of the terminated end is much larger than the other.

On account of the excellence of the signals, an axial ratio was calculated from the measurements. From the prism faces values for $\dot{a}$ were obtained and values for p_o and q_o were obtained from the pyramids and domes (the crystals being measured on the two-circle goniometer). From 44 values for $\dot{a}$ and 70 values for c, the following are obtained which come very close to the accepted value:

$$\dot{a} = \cdot 8146$$
$$c = 1 \cdot 3126.$$

Art. XXXIV.—*Pre-Cambrian Rocks of the Georgetown Quadrangle, Colorado;** by Sydney H. Ball.

Introduction.

In the summer of 1904 a geological survey of the Georgetown (Colo.) quadrangle was made by the writer under the supervision of Mr. J. E. Spurr and with the assistance of Mr. O. H. Hershey. To each the writer gratefully acknowledges great indebtedness. The present paper is a preliminary description of the pre-Cambrian formations exposed in this region.

The Georgetown quadrangle is situated in the center of the north half of Colorado and lies between the meridians 105° 30′ and 105° 45′ west longitude, and the parallels 39° 30′ and 39° 45′ north latitude. The northeast corner of the quadrangle is 26·5 miles west of Denver. Idaho Springs and Georgetown are the principal towns.

Topography.

Relief.—Situated upon the east slope of the Colorado or Front Range, the region is one of high elevation and of great relief. Massive Mount Evans (14,260 feet) is the highest peak in the quadrangle and is the center from which the main ridges radiate. The lowest elevation is 7,450 feet, in the valley of Clear Creek at the eastern edge of the quadrangle.

Drainage.—The streams are all mountain torrents of steep grade. The northern and central portions of the quadrangle are drained by tributaries of the South Platte River, including Clear Creek, its affluents, and the headwaters of Bear Creek. The southern portion of the quadrangle is drained by tributaries of the North Fork of the South Platte.

Evolution of topographic forms.—From a point commanding a wide view of this portion of the Colorado Range, three distinct topographic forms are recognizable; first, an ancient, mature mountainous upland; second, V-shaped valleys incised in this upland; and third, glacial cirques developed at the heads of some of the valleys, passing below into U-shaped valleys.

The mountainous upland over considerable areas in the east central and southeastern portions of the quadrangle has been but little modified by recent erosion, and remnants of the old surface are preserved on the crests of ridges throughout the quadrangle. The mountainous upland was an ancient land surface with about the same differences in altitude as those of the present surface. Dome-shaped mountains and smooth

* Published by permission of the Director of the U. S. Geological Survey.

ridges, however, existed where sharp peaks now are, and the valleys between were broader and less steep than those of the present streams. The drainage was dendritic and mature, the surface being adjusted to the structure of the underlying rocks and to the varying resistances to erosion of the different formations. Lakes did not then exist. The period at which this mountainous surface reached maturity is unknown, but it was probably in late Tertiary or early Pleistocene time.

After the old upland had been formed, deformation increased the gradient of the streams and they cut the present canyons, straight-walled and beset with pinnacles and rugged ribs of rock, in the old broad valleys. The valley-heads of these revived streams were afterward occupied by alpine glaciers of two distinct epochs. The glaciers eroded cirques, arêtes, U-shaped valleys, hanging valleys and lake basins, and by the deposition of lateral, terminal and ground moraines further modified the topography of the upper portions of the valleys.

General Geology.

Preliminary outline.—The rocks of the Georgetown quadrangle, with the exception of Pleistocene deposits and intrusive igneous rocks possibly of Tertiary age, belong to the pre-Cambrian complex of the Colorado Range. The oldest rocks, named in this article the Idaho Springs formation, are crystallines probably of sedimentary origin. These rocks have been most intricately injected by a series of holocrystalline igneous rocks, presumbly of pre-Cambrian age. So intense is injection that the rocks of the quadrangle may be considered an immense igneous breccia, exposure after exposure being encountered in which it is difficult to decide whether to map it as the older rock intruded by the younger, or as the younger rock with inclusions of the older. Some idea of the complexity of injection may be gained from the fact that in a distance of one mile, on the ridge between Silver Creek and Clear Creek, six formations alternate seventy-six times, or at the rate of one alternation to 70 feet. This is exclusive of a number of minor injections and inclusions.

That the injections of the pre-Cambrian igneous rocks took place at widely separated periods is shown by the different degrees of schistosity developed in the different formations. The granitoid habit of the igneous rocks and the character of their metamorphism indicate that the present surface during the whole period of pre-Cambrian intrusion was buried beneath deep masses of overlying rocks.

At three points near Chicago Creek, at elevations of from 9,200 to 10,100 feet, residual bowlders of red or brown silicified sandstone are rather abundant. Pebbles of the pre-Cambrian granites are contained. Outcrops of lithologically similar

sandstone occur on the North Fork of the South Platte one mile above Shawnee and at Pine Post Office on the same stream, both localities being south of the Georgetown quadrangle. The sandstone is lithologically like certain facies of the lower Wyoming of the foothills of the Front Range. It is possible that in Mesozoic time the quadrangle or a portion of it was submerged beneath the sea. In comparatively late, probably Tertiary time, dikes, sheets and stocks of siliceous and intermediate igneous rocks intrude the pre-Cambrian complex. Within the quadrangle there is no evidence that these ever reached the surface and formed flows, although they may have done so. Certain of these rocks are somewhat like some of the andesitic pebbles in the Denver formation* of the Denver Basin and others are somewhat similar to dikes which cut the Lower Wyoming formation near Boulder, Colorado. The evolution of the land surface and the two periods of Pleistocene alpine glaciation have already been mentioned.

The stratigraphic succession of the formations of the Georgetown quadrangle from the top down follows :—

Recent.—Alluvium
Alluvial fan deposits
Landslides
Talus
Travertine.

Pleistocene.—High Basin debris sheets (sheets of rock debris at the heads of non-glaciated streams; indicating pre-glacial downcutting and late glacial filling).

Later glacial deposits, including lateral, terminal and ground morainal deposits and overwash gravels.

Gravels of terrace 25 feet above present stream channels.

Gravels of terrace 55 feet above present stream channels (possibly pre-Glacial).

Earlier glacial deposits, lateral and ground morainal deposits, and terminal morainal deposits in the adjoining Central City (Colo.) quadrangle to the north.

Gravels of terrace 180 feet above present stream channels.

Tertiary.—? Intrusive igneous rocks of widely varying character in dikes, sheets and stocks.

Mesozoic.—? Sandstone residuals.

Pre-Cambrian.—Pegmatites and contemporaneous granite and granite-porphyry.

Silver Plume granite.
Rosalie granite.
Quartz-monzonite.
Quartz-bearing diorite. } Probably contemporaneous.
Gneissoid granite.
Quartz monzonite gneiss.

Idaho Springs formation (biotite-sillimanite-schists, biotite-schist and quartz-gneiss with lenses of silicate rocks).

* Cross, W., U. S. Geol. Survey. Monograph XXVII, pp. 315–6.

Pre-Cambrian Rocks.

The Idaho Springs Formation.

Name.—The name Idaho Springs formation is applied to a series of interbedded, metamorphic, crystalline rocks, presumably of sedimentary origin, which are typically exposed in the hills surrounding Idaho Springs.

Distribution.—The formation is widely distributed over the quadrangle and there is scarcely a square mile in which it does not occur in areas of some size injected by igneous rocks or as shattered fragments included in them.

Petrography.—The Idaho Springs formation includes four intensely metamorphosed crystalline members, three of which, the biotite-sillimanite schist, the biotite-schist, and the quartz-gneiss, are interbedded with and grade into one another, while the fourth, the lime-silicate rocks, although interbedded with the others, appears only to grade into the quartz gneiss.

The biotite-sillimanite-schist is a foliated and often intensely crenulated, normally fine-grained black rock which on weathered outcrops has a rusty appearance. Biotite, quartz, feldspar and sillimanite are always recognizable megascopically, and muscovite, garnet, tourmaline and corundum are sometimes prominent. Sillimanite occurs in single rods and bundles of rods elongated in the plane of schistosity and these are cut by transverse fractures whose interstices are filled by biotite flakes. The biotite-sillimanite-schist is injected lit-par-lit by an ancient pegmatitic rock and it also often contains "eyes" of a more modern pegmatite, which will be referred to later.

Microscopic examination shows the texture to be that of a typical schist, the constituents all having a common parallel alignment, that of the biotite and muscovite plates and the sillimanite rods and bundles being very pronounced. The feldspars prove to be orthoclase and microcline with some plagioclase (albite or an acid oligoclase, rarely andesine) whose twinning is notably uneven. Quartz and orthoclase are often micropegmatically intergrown and in a rock which has suffered such profound metamorphism it seems probable that this texture originated during recrystallization. Sillimanite was produced largely at the expense of feldspar, and to a less extent of biotite. Sillimanite, in turn, sometimes alters to a kaolinitic material. Zircon, apatite and magnetite, rather constant accessory minerals, are only of interest from the fact that the last two often show a distinct orientation parallel to the plane of schistosity. Corundum, andalusite, and in part garnet, muscovite and tourmaline are clearly later than the major recrystallization of the rock, and from field relations are considered products of contact metamorphism.

The biotite-schist is differentiated from the type just described by a finer grain, a less perfect schistosity (continuous films of biotite being absent), by a medium or light gray color, and by the almost total absence of muscovite and sillimanite. Small segregations of magnetite surrounded by white halos from which they have abstracted all the ferromagnesian minerals are rather common.

The quartz-gneiss is a well banded, dense, vitreous rock varying in color from gray to brown, red or black. Quartz greatly predominates over all other constituents, which include most of those present in the biotite-sillimanite-schist. Under the microscope the gneiss is composed of intricately interlocking quartz lenses elongated parallel to the banding, the darker color of certain bands being due to magnetite cubes in discontinuous rows. The quartz-gneiss is exposed for a distance of one-half of a mile on Sugarloaf Peak.

Distributed in bands in the three types of the Idaho Springs formation already described, but particularly characteristic of the biotite-schist, are white ellipsoidal masses from one-half to four inches in length. These sharply bounded masses are flattened parallel to the plane of schistosity and in some instances are mashed to paper-thin sheets. They are composed of quartz and sillimanite, other minerals being present only in small amounts. The ellipsoidal masses occur widely over the area, but are particularly well developed on Chief and Pendleton mountains.

The silicate rocks of the Idaho Springs formation, which include many intergrading facies of widely varying composition and texture, grade into the quartz-gneiss. The facies are hornblende-augite-feldspar-gneiss, quartz-magnetite-gneiss, and several kinds of massive rocks. These massive rocks include coarse-grained aggregates of quartz, epidote and brown garnet in varying proportions with texture of a miarolitic pegmatite, and lime-silicate rocks composed of dominant calcite with smaller amounts of scapolite, grossular garnet, bottle-green pyroxene and quartz. The microscope shows calcite to be rather widely distributed and titanite to be a common accessory mineral in the silicate rocks of the Idaho Springs formation. Perhaps the most striking textural peculiarity is the presence of micropegmatitic intergrowths of epidote and zoisite, epidote and garnet and calcite and garnet, all clearly the products of recrystallization. The silicate rocks are well exposed in the vicinity of Alpine Peak.

Origin of the Idaho Springs Formation.—The Idaho Springs formation has been so greatly metamorphosed that all original textures have been destroyed. The lithologic variation across apparently bedded bands suggests a sedimentary

series, while the bands containing the ellipsoidal masses are most naturally regarded as conglomerates. The quartz-gneiss is present in such thick masses that it can scarcely be of pegmatitic or vein origin and probably represents intensely metamorphosed sandstone. The silicate rocks would in this interpretation of the origin of the formation represent calcareous sandstones and impure limestones, while the biotite-sillimanite-schist and biotite-schist would be metamorphosed shales and arkoses. The abundance of aluminum silicates in the series and the similarity to metamorphic rocks of known sedimentary origin strengthens the view of the supposed sedimentary origin of the Idaho Springs formation. This formation then may be regarded as an intensely metamorphosed series of shales, arkoses, sandstones, conglomerates and impure limestones.

Age.—The Idaho Springs formation is the oldest member of the pre-Cambrian series in the Georgetown quadrangle, and it forms the network into which the other formations were injected. The pre-Cambrian quartzite of South Boulder Creek (Colorado), described by Dr. C. R. Van Hise,* lies unconformably upon a granite which in the amount of mashing suffered and in lithological character somewhat resembles the Silver Plume granite later to be described. While the gap of 18 miles between Idaho Springs and South Boulder Creek has not been traversed, it is believed that the Idaho Springs formation is vastly older than Van Hise's pre-Cambrian quartzite.

Hornblende-Gneiss.

Distribution.—The hornblende gneiss has a wide distribution, especially in the southern portion of the quadrangle. It occurs in sheets and dikes in the Idaho Springs formation and may have formed surface flows.

Petrography.—The hornblende-gneiss is typically a rather fine-grained, well-banded rock in which white laminae of quartz and feldspar alternate with black or greenish-black layers of hornblende. Biotite is developed at the expense of hornblende where maximum movement has occurred, and along shear planes the rock passes to a biotite-hornblende-schist. Aggregates of hornblende or biotite, or both, give a porphyritic aspect to certain facies. Rather massive, fine-grained facies occur but are rare.

The microscope shows the banding to be partially a segregation into laminae of like minerals during recrystallization and partially a result of lit-par-lit pegmatitic injections. The parting parallel to the banding is largely due to the common

*U. S. Geol. Surv. Bull. 86, p. 325.

elongation of the ragged hornblende prisms, and to a somewhat imperfect orientation of the hornblende cleavage. Hornblende and biotite together form over one-half the rock, while plagioclase, usually labradorite, and smaller amounts of orthoclase and quartz are the other essential constituents. Titanite, apatite, zircon and ilmenite or magnetite are accessories, and augite, epidote and pyrite are sometimes present. The more massive facies show traces of igneous texture, one rock from the west bank of Soda Creek, .8 of a mile south of Idaho Springs, being a metadiabase of ophitic texture in which the ferromagnesian mineral is hornblende.

Age.—The hornblende-gneiss cuts the Idaho Springs formation and is therefore younger. The gneiss itself is cut by the other igneous rocks of the quadrangle. From the excellent schistosity developed over wide areas in this much metamorphosed basic igneous rock, it is probably almost as ancient as the Idaho Springs formation.

Quartz-Monzonite-Gneiss.

Distribution.—The quartz-monzonite-gneiss is widely distributed, particularly in the central and southern portions of the quadrangle. The largest area is on Paines Mountain.

Petrography.—The quartz-monzonite-gneiss is a gray, medium-grained gneissic rock which is normally porphyritic. The gneissic structure is due to the segregation in alternating bands of quartz and feldspar and of biotite and hornblende. The parting parallel to the gneissic structure is seen, under the microscope, to be due to the parallel orientation of biotite blades through recrystallization and to a slight elongation of the hornblende individuals parallel to the schistosity. The orientation of the hornblende is probably largely due to the more vigorous attack by solutions upon those hornblendes of the monzonite at right angles or highly inclined to the plane of developing schistosity than those whose elongation was originally parallel to it. Apatite, zircon and titanite in certain instances show marked parallelism to the gneissic structure, indicating the extreme recrystallization to which the rock has been subjected.

Rudely ellipsoidal white porphyritic striated feldspar crystals lie in the medium-grained schistose aggregate of biotite, feldspar, hornblende and quartz. These feldspars are aligned parallel to the gneissic structure and have suffered the same deformation as the smaller constituents of the rock. The quartz-monzonite-gneiss near West Geneva Creek contains also pink microcline phenocrysts, sometimes 2 inches long, often twinned according to the Carlsbad law. These have perfect crystal outlines with their longest axis at right angles to the gneissic structure even in the most metamorphosed groundmass.

Microscopic examination shows that they are uncracked while the feldspars of the groundmass are fractured. They are without much doubt of metamorphic origin and were formed after the rock became a gneiss. In certain exposures these microcline feldspars have been mashed by later deformation into ellipsoids and even into ribbon-like masses.

The original rock was a porphyritic quartz-monzonite, in some facies of which the alkali feldspar is so subordinate that the rock becomes a granodiorite. Plagioclase is more abundant than the other essential constituents, quartz, microcline, orthoclase, biotite and hornblende, and of these latter any one may predominate. Hornblende, however, is not present in some slides. The plagioclase in the "groundmass" and the ellipsoidal porphyrite crystals is either oligoclase or andesine. The porphyritic plagioclase is characterized by zonally arranged magnetite cubelets, and by rods, hexagonal plates, and dots, probably of hematite. Micropegmatitic intergrowths of quartz and each of the three feldspars occur along the borders of the grains. The alterations of biotite are interesting in that when hornblende is present epidote is the major alteration product, while, on the other hand, when hornblende is absent, chlorite or muscovite accompanied by rutile needles is the alteration product. The rock is characterized by the unusual abundance and coarseness of the accessory minerals, magnetite, titanite, apatite, zircon and pyrite. Pyrite is usually surrounded by or intergrown with magnetite.

Age.—The quartz-monzonite-gneiss intrudes and includes fragments of the Idaho Springs formation and the hornblende-gneiss. It is in turn cut by the gneissoid-granite and the igneous rocks which succeed it. While in some exposures its age relations with the Idaho Springs formation, the hornblende-gneiss and the gneissoid-granite are clear, the quartz-monzonite-gneiss usually contacts with these in a sharp line with parallel gneissic structure. South of Naylor Lake some exposures occur in which the Idaho Springs formation and the quartz-monzonite-gneiss seem to grade into one another, apparently as the result of the absorption of the schist by the monzonite when injected.

The close resemblance in mineral composition of the quartz-monzonite-gneiss to the quartz-monzonite is striking, forming a good example of the repetition of a monzonite injection.

Gneissoid-Granite.

Distribution.—Stocks and dikes of gneissoid-granite injecting the formations already described are widely distributed in the quadrangle. The gneissoid-granite covers large areas in the southwestern corner of the quadrangle and numerous

smaller areas occur east of Georgetown and west of Idaho Springs.

Petrography.—The gneissoid-granite is a fine to even-grained granite, more or less gneissoid, which is gray when fresh, and flesh pink to yellowish brown when weathered. Feldspar, quartz and biotite are visible to the naked eye, although the last is sometimes practically lacking. Muscovite plates, which reach a maximum diameter of one-half of an inch and enclose the other constituents poikilitically, are locally prominent. Magnetite, pink garnet, and sillimanite are occasionally visible.

The quartz under the microscope is of the normal granitic type except for the abundant inclusion in many of the grains of needle-like opaque microlites. Orthoclase and microcline greatly predominate over oligoclase or a related acid plagioclase. Micropegmatitic intergrowths of each of the feldspar species with quartz occur. The content of microcline, often microperthitic, increases with increase in the recrystallization to which the rock has been subjected, and, in consequence, is absent in some slides and is the predominant feldspar in others. While some microcline may be original, the larger portion is certainly of secondary origin. It occurs in wedges and hook-like masses which sometimes separate quartz or orthoclase fragments of similar orientation; again, elongated areas are arranged end to end as if forced into planes of weakness. In other cases altered plagioclase or orthoclase grains are dotted by fresh areas of microcline similarly oriented and elongated parallel to the cleavage of the orthoclase or the albite twinning of the plagioclase. The host is often fractured and unshattered microcline bridges the crack, while a narrow rim of orthoclase or plagioclase next the microcline is fresh, in contradistinction to the altered feldspar of the main mass. While clearly later than the other feldspars, the time at which this microcline formed is unknown.

Biotite has no unusual features. The poikilitic muscovite plates, already mentioned, grade into sericitic shreds, the alteration product of the feldspar, and are themselves secondary. Sillimanite, which has also been previously mentioned, occurs in parallel aggregates in the center of muscovite plates and may be one of its alteration products. The accessory minerals constantly present are zircon, apatite and magnetite, while ilmenite and garnet sometimes occur.

The granite magma when injected must have been very fluid since it inserted itself between the folia of the earlier gneisses and replaced in a marked degree inclusions of the Idaho Springs formation. Dark bands in scroll-like patterns of more basic granite preserve the outlines of schist inclusions,

while lace-like shreds of biotite often suggest the forms of original inclusions now almost totally absorbed. Similar phenomena are referred to at greater length under the pegmatites and associated granites and granite-porphyry. (See page 386.)

The rock varies, often in the same exposure, from an almost massive to a banded rock in which quartz and feldspar layers are separated by discontinuous sheets of aligned biotite plates. Microscopic examination shows that the gneissoid structure is due largely to recrystallization and partially to granulation. The more gneissoid facies occur about the border of large areas of granite or around gneiss inclusions.

Age.—The gneissoid-granite injects and encloses portions of the formations already described and is, in turn, included in and cut by the quartz-monzonite and the succeeding igneous formations.

Quartz-Monzonite.

Distribution.—A large irregularly shaped batholith of quartz-monzonite, which disappears beneath the older rocks at rather low angles, occupies the central, north central and east central portions of the quadrangle. Minor intrusive masses are rather widely distributed.

Petrography.—The quartz-monzonite is a gray to bluish-gray, medium-grained, granular rock, often more or less porphyritic in habit. Macroscopically, feldspar, quartz, biotite and hornblende are essential constituents, while magnetite and titanite are accessories. In the porphyritic facies rather good crystals of pink microcline feldspars, which are usually twinned according to the Carlsbad law, reach a maximum length of 1 inch. A matted coating of tiny epidote crystals occurs rather characteristically along many joint fractures.

The texture upon microscopic examination proves to be hypidiomorphic granular, rather even-grained in the non-porphyritic and uneven in the porphyritic. With variation in the relative amount of the alkali and lime-soda feldspars, the rock varies from an acid to a basic quartz-monzonite with granodioritic affinities. The essential minerals in the order of their abundance are oligoclase or andesine, microcline often microperthitic, quartz and biotite, and orthoclase and hornblende if present. The accessory minerals, magnetite, apatite, pyrite and zircon, are particularly abundant. The order of the solidification is normal, although the period of the separation of biotite overlapped that of titanite, and it in turn was overlapped by that of plagioclase. Quartz is micropegmatitically intergrown with each of the feldspar species. Needle-like opaque microlites are characteristic interpositions in quartz, and magnetite cubelets and hematite in hexagonal plates occur

in plagioclase. Apatite grains in quartz are sometimes deeply embayed and resemble the familiar corroded quartz phenocrysts of rhyolite.

Near the borders of the batholith a rude gneissoid structure is developed which microscopic examination proves to be in part original and due to flow orientation of the phenocrysts and biotite in a common plane, and in part a secondary structure due to granulation and slight recrystallization.

Age.—Field observation shows that the quartz-monzonite is younger than the gneissoid granite and older than the Rosalie granite. Its relation to the quartz-bearing diorite will be discussed under that formation.

Quartz-Bearing Diorite.

Distribution.—Quartz-bearing diorite occurs in small stocks and dikes which are largely confined to the northern one-fourth of the quadrangle and are particularly abundant south of Idaho Springs and northeast of Georgetown.

Petrography.—The quartz-bearing diorite is a medium to coarse-grained, rather uneven, granular rock, composed of grayish-white striated feldspar, greenish-black hornblende, and a little quartz. Biotite plates, which reach a maximum diameter of 2 inches, poikilitically enclose the other constituents at some exposures. Epidote occurs in matted films on joint faces and in rude pseudomorphs after hornblende and biotite in the rock mass.

Under the microscope the texture is allotriomorphic or with the partial development of plagioclase individuals hypidiomorphic granular. The order of crystallization of the minerals is normal, except that biotite in some cases solidified simultaneously with orthoclase and quartz. Plagioclase varies from andesine to bytownite, a basic labradorite being the most common species. It is characterized, as are quartz and orthoclase in a less degree, by a vast number of minute tabular and circular interpositions which are black and opaque or clove-brown and translucent. Plagioclase is altered more or less completely to sericite, zoisite and quartz. Green hornblende, in elongated grains, often twinned parallel to 100, is usually riddled with blebs of the other constituents. Quartz, which with orthoclase forms wedges between hornblende and plagioclase, is micropegmatitically intergrown with each species of feldspar, biotite and hornblende. Diallage, filled with the opaque inclusions characteristic of the species, and surrounded by secondary cores of hornblende, is a rather rare constituent, although its presence is not surprising in view of the basic nature of the plagioclase. In the alteration to hornblende the dark inclusions of the diallage disappear, their substance

apparently being absorbed in the production of the hornblende. Large poikilitic plates of biotite have already been mentioned as characterizing some outcrops and small biotite blades are rather constant constituents. Biotite is also secondary to hornblende. The accessory minerals include magnetite, ilmenite, pyrite, and large and abundant crystals of apatite. Zircon and rutile are less common. Apatite crystals enclosed in feldspar have embayed borders as if magmatically corroded.

Diorite upon the borders of the intrusive masses is sometimes mashed to a gneissoid rock partly through recrystallization and partly through granulation. Hornblende and feldspar are segregated into lenses rudely elongated parallel to the parting, and blades of biotite and a colorless amphibole, probably anthophyllite, are developed parallel to the gneissic plane. The albite twins of the plagioclase are sometimes aligned parallel to the gneissic structure, while the undulose extinction of orthoclase passes into the "gitter" structure of microcline, the latter mineral being clearly secondary to the former and occurring solely in mashed facies of the diorite.

Associated with the diorite and linked to it by some gradational facies are fine-grained, granular rocks of greenish black color which are perhaps best styled hornblendites. Under the microscope some of these, with the exception of minor quantities of plagioclase, quartz and accessory minerals, are formed of green hornblende; others are made up of large irregular green hornblende individuals enclosing poikilitically laths of biotite, grains of enstatite showing schillerization and partial columns of a colorless amphibole, probably anthophyllite. In some slides this amphibole, which alters to talc, is as abundant as hornblende. Still another of these rocks is in one portion of the slide composed entirely of hornblende and in another largely of white monoclinic pyroxene near malacolite. These fine-grained rocks have suffered considerable recrystallization and their original character is in doubt.

Age.—The quartz-bearing diorite bears the same structural relations to the other formations of the Georgetown quadrangle as does the quartz-monzonite. The contact of the two formations is nowhere well exposed in the quadrangle, although intermediate types indicate that the two may be variants of the same magma. Near St. Mary's Lake, north of the Georgetown quadrangle, the two appear at some places to grade into one another and in others the diorite clearly cuts the quartz-monzonite. The two are believed to be differentiation products of the same magma, the quartz-bearing diorite on the whole being slightly younger.

Rosalie Granite (Biotite-Granite).

Distribution and Name.—Exposures of the Rosalie granite are confined to the southern portion of the Georgetown quadrangle. The type locality is that in the southeast corner of the quadrangle on Deer and Elk creeks, where the granite weathers into dome-shaped hills and gentle valleys, covered by mushroom-like forms of granite. A second area forms the ridge between Mount Evans and Mount Rosalie and the granite is named from the latter peak.

Petrography.—The Rosalie granite is a coarse grained, massive, granular rock whose predominant constituent is a salmon-pink microline often showing Carlsbad twinning. These feldspars, which vary in length from one-half to two and one-half inches, are rudely tabular in form and are separated from one another by ramifying bands of quartz, feldspar, biotite and magnetite, all of medium size.

Under the microscope the texture is uneven and hypidiomorphic granular. The essential constituents of the rock began to separate in the order usual in granites, but the periods of separation of all overlapped, and in consequence each constituent encloses blebs and partial crystals of the others. Magnetite in some cases separated simultaneously with quartz and feldspar. The minerals in the order of their abundance are microcline, quartz, orthoclase, oligoclase and biotite. Microcline, often microperthitic, contains hexagonal plates, dots and rods of hematite. These interpositions also occur frequently in plagioclase and less frequently in quartz, and in association with them in the latter mineral are opaque hair-like inclusions. Quartz at its contact with the various feldspar species and biotite forms micropegmatitic intergrowths. Zircon, apatite and magnetite are constant accessory minerals, while muscovite, titanite and pyrite are less frequent. With the exception of minor granulation, the Rosalie granite is but little deformed.

Age.—The Rosalie granite cuts the quartz-monzonite and in turn is intruded by dikes of apparently the Silver Plume granite described below.

Silver Plume Granite (Biotite-Granite).

Distribution and Name.—Stocks, dikes and irregular intrusive masses of the Silver Plume granite are especially well developed in the vicinity of Georgetown, north of Meridian Hill and on Alps Mountain, but occur widely distributed throughout the quadrangle except in the extreme northeast and southeast corners. It forms the south wall of the Clear Creek canyon at the mining town of Silver Plume and it derives its name from this village.

Petrography.—The Silver Plume granite is a medium-grained hypidiomorphic granular rock which by the increase in size of the pinkish-white porphyritic feldspars (Carlsbad twinned microcline) and the decrease in size of the encircling quartz feldspar and biotite individuals passes near the contact with older rocks into granite-porphyry. Some of the smaller dikes are wholly of the granite-porphyry facies. The granite at some localities is notably rich in biotite and is then dark gray in color mottled by the pink feldspars; at other localities the biotite content is normal and the rock is pinkish-gray.

Under the microscope the essential constituents of the granite in descending order of abundance are alkali feldspars, quartz, biotite and oligoclase and oligoclase-albite. Original muscovite is lacking in some slides, in others it is associated with biotite, and in certain rare instances is the only mica present. Muscovite also forms large plates which poikilitically enclose quartz globules; these plates grade into sericitic shreds secondary to orthoclase and are themselves evidently secondary to feldspar. The order of the consolidation of the minerals from the magma is normal, although the periods of separation somewhat overlapped each other. Quartz is of chief interest from the constant presence in it of thread-like opaque inclusions; these are less abundantly present in feldspar. Of the alkali feldspars, microcline, often with microperthitic bands, predominates in some slides and is lacking in others. While sometimes occurring in secondary veins in orthoclase and oligoclase, it is in the main an original constituent. Among the accessories zircon and apatite are abundant, magnetite rather common, and ilmenite, pyrite, titanite and rutile rare.

The phenocrystic feldspars near the contacts of the granite mass are arranged in well defined planes which follow the sinuosities of the contact. The rock has not been recrystallized and the parallel orientation and the poorly defined cleavage consequent thereto are original structures due to movements in the magma prior to final solidification. Secondary gneissic structure has only been formed over small areas subjected to unusual dynamic movement.

Age.—The Silver Plume granite cuts all of the formations previously described and with the exception of the pegmatite and associated granite and granite-porphyry is the youngest member of the pre-Cambrian formations.

Pegmatite and Associated Granites and Granite-Porphyry.

Distribution.—These rocks, the youngest of the pre-Cambrian formations, nowhere form large areas, but are, on the other hand, present in small bodies in almost every outcrop in the quadrangle.

Pegmatite.— While each of the granular igneous rocks already described grades into a pegmatite, the pegmatite of most interest is that which intrudes or grades into the youngest pre-Cambrian granites and granite-porphyry. In a single exposure the pegmatite and granite may grade into one another at one point and at another the rocks may be sharply differentiated, the pegmatite as a rule being younger.

Salmon-pink feldspar, either orthoclase or microperthitic microcline, is usually the predominant mineral of the pegmatite. A greasy-gray, acid plagioclase is restricted in its distribution to pegmatite dikes in the quartz-monzonite. Slightly smoky quartz, which microscopic examination shows to contain abundant opaque thread-like interpositions and myriad fluid inclusions, is always present and, in the tiny banded quartz apophyses which are given off from the large dikes, it is the only constituent of the pegmatite. Biotite is more common than muscovite and the two micas characteristically occur in separate bodies of pegmatite, although they are sometimes associated in the same masses and in rare instances a core of biotite is surrounded by a muscovite border. An interesting form of pegmatite is composed of diamond-shaped muscovite plates up to 1 inch in diameter embedded in quartz, each mineral being present in nearly equal amounts. The rock is closely allied to beresite from the Ural mountains and to a rock described by Mr. J. E. Spurr from Belmont, Nevada.*

Magnetite is a widely distributed constituent and in some cases forms over one-third of the pegmatite mass, which in consequence becomes a lean iron ore. Magnetite occurs in octahedral crystals of a maximum diameter of 4 inches or in irregular aggregates up to 6 inches across. It is in some instances the only femic mineral of the pegmatite, but is usually associated with biotite and less often with muscovite.

Black tourmaline is a widely distributed but never abundant mineral in the pegmatites. It occurs either in crystals embedded in quartz or orthoclase, in micropegmatitic intergrowths with quartz and feldspar, in feldspar metasomatically replacing it or in felts along cracks in the pegmatite. Hence while tourmaline usually solidified prior to quartz and feldspar, it sometimes solidified contemporaneously with them and rarely after them. The femic mineral usually associated with tourmaline is muscovite, both of which minerals from other localities usually contain some fluorine. Red garnets are locally very abundant in the more siliceous pegmatites. Rare constituents include allanite, apatite, hornblende, beryl and a quartz-feldspar pseudomorph, probably of spodumene.

* This Journal, vol. x (1900), p. 351.

The pegmatite dikes are sometimes rudely banded, quartz being usually segregated in the center. Such banded dikes along their strike pass into coarsely granular pegmatite. The various textures of the pegmatites and the granular texture of the granite sometimes grade into one another in a single outcrop 100 feet in diameter, and in consequence the physical conditions which in some cases determined the production of one texture could have varied little from those which produced others.

While typically massive the pegmatites are locally mashed into gneisses, partly by granulation and partly by recrystallization. Quartz-magnetite pegmatite was particularly subject to recrystallization, producing a quartz-magnetite-gneiss in which eyes and thin bands of magnetite lie in quartz. The pseudomorphous gneissic structure sometimes present in pegmatite surrounding schist inclusions will be described later.

The magma appears to have varied from a comparatively dry magma from which the granites solidified, through molten masses rich in water from which some of the pegmatites solidified, to a body so saturated with water that the banded quartz veins deposited by it resemble water-deposited veins.

The extreme fluidity of the magma which deposited the pegmatites is indicated by a number of characteristics of that rock. The pegmatitic magma or fluid sought out the smallest cracks and crevices and deposited its material therein, and the presence of pegmatite in small masses in nearly every outcrop in the quadrangle indicates that the older rock masses were thoroughly saturated with the pegmatitic material. That the process was one of saturation rather than ordinary igneous injection is shown by the presence in the biotite-sillimanite-schist of the Idaho Spring formation of isolated lenticular "eyes" of pegmatite similar to that of the larger pegmatite masses. The constituents of these "eyes" are absolutely uncrushed and cannot be considered segments of a sheared pegmatite dike. The pegmatites further absorbed considerable masses of this schist and from the center of the larger inclusions gradations occur in certain instances from pure schist to schist containing thin bands of pegmatite along its folia, thence to pegmatite in which only a few scroll-like figures of darker pegmatite faintly suggest the crenulations of the almost totally absorbed schist, and lastly to pure pegmatite. In the latter, however, a fair parting is sometimes preserved, indicating that the structure of the schist is partially preserved by metasomatic replacement, and the parting may be considered a pseudomorph of that of the schist.

A further proof of the extreme fluidity of the pegmatite magma is the influence upon the mineral composition of the

pegmatite exerted by the rock in which the pegmatite was injected. Biotite is the characteristic femic mineral of pegmatites which inject the granites already described, the quartz-monzonite-gneiss, the quartz-bearing diorite, and the hornblende gneiss, although hornblende is often the typical dark mineral of pegmatites in the last two formations. Muscovite is the typical femic mineral of pegmatite dikes in the Idaho Springs formation, and 98 per cent of the occurrences are in this formation. The pegmatite dikes in quartz-monzonite areas are characteristically without femic minerals and often contain, instead of an alkali feldspar, a soda-lime feldspar. Magnetite alone of the abundant femic constituents of the pegmatites is not influenced by the rock intruded and was evidently an original constituent of the pegmatite magma. In areas of unusually complex injection where the Idaho Springs formation and the granular igneous rocks are in approximately equal development, both biotite and muscovite are often associated with one another. Where the pegmatite passes from a fairly large area of granite to an area of the Idaho Springs formation, the substitution of muscovite in place of biotite is usually coextensive with the boundaries of the two formations. Where, on the other hand, the pegmatite has traversed a single formation for a long distance and then passes to a second formation, there is a distinct "lag" in the introduction of the mineral characteristic of the pegmatite in the second formation. This is well seen on the north side of the quartz-monzonite batholith where the quartz-feldspar pegmatite extends several hundred yards into the biotite-sillimanite-schist of the Idaho Springs formation, before muscovite, the characteristic mineral of pegmatites in that formation, is present.

A chemical discussion of these observations is impossible, since the composition of the pegmatite is unknown. It is indeed probable that the pegmatitic substances left the cooling mass of granite at widely varying times and at their birth probably varied in chemical composition. Field evidence, however, indicates that the pegmatitic substances prior to solidification abstracted sufficient material from the enclosing rocks to materially modify their chemical composition. The lag already mentioned indicates that the change in composition did not occur immediately upon entering a formation, but only after the pegmatitic magma had traversed it for some distance.

The Granites and Granite-Porphyry.—The granites associated with the pegmatites are massive granular rocks characterized by a fine or medium-grained allotriomorphic texture. While the granites intergrade, not only with pegmatite but with one another, certain types are rather well defined.

In the northern part of the quadrangle a white medium-grained muscovite-granite, which often has pink garnet as an abundant accessory, grades into muscovite-pegmatite. North of Georgetown the granitic rock is a gray muscovite-bearing alaskite in which quartz predominates over feldspar. In the central or southern parts of the quadrangle a pink or pinkish gray fine-grained biotite-granite predominates. The same granite in the southeast corner of the quadrangle is medium-grained.

Under the microscope the order of crystallization is normal except that the rare accessory mineral titanite in certain instances lies in irregular grains between quartz and feldspar and therefore separated simultaneously with them. Microcline, usually with microperthitic bands, is the predominant constituent of most of the granites. Orthoclase and an acid plagioclase, oligoclase-albite, are also usually present. Quartz forms micropegmatitic intergrowths with the three species of feldspars and is further characterized by abundant thread-like inclusions. Biotite and muscovite are in no way peculiar although original muscovite is more widely distributed than in any other granite of the quadrangle. Zircon, magnetite and apatite are common and abundant accessory minerals, while titanite, garnet and fluorite sometimes occur.

In the southeastern portion of the quadrangle pegmatite and the associated granite grade into pink granite-porphyry. The groundmass is a fine-grained microgranitic aggregate of microcline and quartz, and in some facies orthoclase and magnetite and in others biotite. The phenocrysts include pink tabular microcline and orthoclase, rounded slightly smoky quartz, biotite and sieve-like hornblende crystals. Titanite and magnetite are accessory. Fluorite is a rather constant accessory of the granite-porphyry and the associated granite. It forms transparent colorless wedges, dotted by deep purple spots, between quartz and feldspars, which in contact with it have slightly rounded faces. Fluid inclusions are fairly abundant. Fluorite occurs in an area ten miles distant from known mineralized veins, and from this and the uniform distribution of the mineral in the slides examined it is believed to have been deposited in minute cavities in the rocks by pneumatolytic action.

Similarity of the Pre-Cambrian Granites.

Although no chemical analyses of the rocks of the Georgetown quadrangle have been made, microscopic examination shows a marked mineralogic similarity in the granites, the intrusions of which were separated in every case by considerable time intervals and in one case by the intrusion of more

basic rocks. The granites are characteristically biotite-granites in which microcline, which undoubtedly is in some cases a product of recrystallization and in others of deformation, is usually the predominant feldspar. Orthoclase in turn predominates over oligoclase or oligoclase-albite. Microcline throughout the series is characterized by microperthite bands which are less common in orthoclase. The presence in quartz of abundant thread-like inclusions of undetermined nature is also characteristic. Biotite appears to contain titanium, since rutile or some other titanium mineral is a by-product of its alteration. Original muscovite, except in certain of the pegmatitic granites, is present in negligible amounts. Of the accessory minerals, apatite, zircon and magnetite are constantly and rather abundantly present. The granites of the Georgetown quadrangle present a rather interesting example of the repeated injection of a granitic magma or magmas of rather constant composition. Mr. E. B. Mathews* emphasized the close chemical and mineralogical similarity of the granites of the Pike's Peak (Colorado) quadrangle, which lies at the south end of the Colorado Range. The granites of this region and those of the Georgetown quadrangle possess many characteristics in common.

* Journal of Geology, vol. viii, pp. 214–240.

Art. XXXV.—*Lower Paleozoic Formations in New Mexico;** by C. H. Gordon and L. C. Graton.

Students of New Mexico geology have hitherto generally agreed in asserting the absence of the older Paleozoic formations in that region. Endlich,† followed by Clark,‡ considered certain limestones and quartzites occurring at the base of the sedimentary section of Lake Valley, Sierra County, to be Silurian, and some quartzites east of the Sandia Mountains, in Sandoval and Bernalillo counties, have been regarded, probably erroneously, as Cambrian.§ With these and possibly a few other exceptions, it has commonly been stated that rocks representing the Lower Paleozoic periods are wanting in the Territory, and that the Carboniferous formations rest directly on granites, gneisses and schists, which are generally considered to be pre-Cambrian, although in some cases the granites are thought to be of later age. This prevailing view has recently been summarized as follows:

"At present there is no reliable evidence that any of the Lower Paleozoic beds are represented within the limits of New Mexico. The great Cambrian, Silurian, Ordovician and Devonian systems which are so extensively developed in other parts of the American continent have thus far failed to be observed in the southern Rocky Mountain region."‖

Herrick states that in southwestern New Mexico occur strata supposed to be older than the Burlington "some of which have been referred to the Devonian (Hamilton)," but adds that "as far north as Socorro County the stratified rocks overlying the granite have revealed no remains indicating an earlier age than the Carboniferous, and the writer knows of no positive datum representing anything older than the Coal Measures."¶

During the past season a reconnaissance study of the mining districts of New Mexico was carried on by the U. S. Geological Survey under the direction of Mr. Waldemar Lindgren. In the prosecution of this study many facts of stratigraphic significance were obtained, and it soon became evident that in certain places pre-Carboniferous strata are present. Although

* Published by permission of the Director of the U. S. Geological Survey.

† The mining regions of southern New Mexico. Am. Nat., vol. 17, pp. 149–157, Feb. 1883.

‡ The silver mines of Lake Valley, N. M., Trans. A. I. M. E., vol. 24, 1895, pp. 138–167.

§ Yung and McCaffery, Trans. A. I. M. E., vol. 33, p. 354, 1903.

‖ Keyes, C. R., Geological formations of New Mexico, Report of Governor for 1903, p. 338. See also U. S. G. S., Water Supply Paper No. 123, p. 20, 1905.

¶ Herrick, C. L., A Coal Measure forest near Socorro, N. M., Journal Geol., vol. xii, p. 238, Apr.–May, 1904.

the studies of these rocks are yet incomplete and their geographical distribution or extent has not been fully defined, sufficient data are at hand to show that resting upon the pre-Cambrian rocks is a series of beds of a maximum thickness of over 2,000 feet which are representatives of the Cambrian, Ordovician, Silurian and Devonian systems, and that these rocks are present along a belt which crosses Grant, Sierra, and Luna counties, and extends from the east side of the Rio Grande westward beyond the Arizona line and probably connects with the similar formations of the Clifton copper district of Arizona.* The localities where these rocks are best exposed are in the Caballos Mountains near Shandon, in the Hillsboro and Kingston mining districts along the east side of the Black Range, in the vicinity of Cook's Peak and the Florida Mountains, and just west of Silver City. Rocks which unquestionably belong in the same systems occur in the Georgetown and Lone Mountain mining districts, and probably in the Telegraph district.

Cambrian.—This system is known to be present in the Bisbee district in southeastern Arizona, and in Texas, and recently Mr. G. B. Richardson of the U. S. Geological Survey has found Cambrian fossils in the Franklin Mountains just south of the New Mexico line.† Rocks which have been referred to this system are known in the Clifton district in Arizona, but heretofore there has been no final proof of the existence of Cambrian formations in northeastern Arizona nor in New Mexico.

The Cambrian rocks in southwestern New Mexico consist of massive and flaggy quartzites, indurated sandstones, sandy shales, all more or less ferruginous, with occasional beds of siliceous limestone. These strata, which vary from 50 to 1,100 feet in thickness, are separated from the underlying pre-Cambrian gneisses and schists by a great erosional unconformity. In the eastern part of the area where these quartzites have been found there appear to be certain well-marked divisions of the rocks. The lowest consists of a coarse, dark brown or red ferruginous quartzite, the lowermost beds of which are conglomeratic. As observed in the Florida Mountains, this division has a thickness of about 60 feet. Overlying these dark quartzites in some places, and replacing them in others, is a white quartzite, sometimes shaded pink, which varies from a few to 75 feet in thickness. In the Shandon district at the base of the Caballos Mountains this white quartzite is only 4 or 5 feet thick, and in places rests directly on the granite. The maximum development of the white quartzite was observed

* Lindgren. W., Clifton Folio, U. S. Geological Survey, No. 129.
† Science, vol. 23, No. 581, p. 267.

in the Florida Mountains, where the uppermost beds alternate with thin beds of limestone, forming a transition to the limestones above. The highest division is a series of beds having a maximum thickness of 40 feet, composed of dark brown and green, sandy shales and thin-bedded quartzites. These latter rocks are well developed in the Caballos Mountains near Shandon, where in certain layers they contain linguloid shells which have been identified by Dr. Charles D. Walcott as *Obolus* (*Westonia*) *stoneanus* Whitfield, a form of the Upper Cambrian, found at Newton, N. J., and in the St. Croix sandstone of Wisconsin. In no one place were all three divisions observed, and it may be the white quartzite is but a local phase of one of the other divisions.

Near Silver City these rocks have a thickness of nearly 1,100 feet. They consist mostly of quartzites of dark red, brown or black color due to iron stain, which contain three beds of cherty limestones 30 to 75 feet thick, and near the top and near the bottom a thin band of shale; a few feet at the very base is a conglomerate.

Ordovician.—A series of limestones, for the most part massively bedded and having a maximum thickness of 1,200 feet, rests conformably upon the Cambrian rocks. The thinly bedded cherty members of the lower portion of this series suggest resemblance to Abrigo limestone of the Bisbee district,* which is Middle Cambrian, but some poorly preserved organic remains found about 100 feet above the quartzite in the Silver City section are regarded by Mr. E. O. Ulrich of the U. S. Geological Survey as belonging certainly in the Lower Ordovician. At this place, where the upper limit is not definite, the limestones considered to be Ordovician are about 770 feet thick, consisting at the bottom of 265 feet of cherty limestone overlain by 185 feet of alternating narrow bands of limestone and chert, and succeeded by about 330 feet of gray or pinkish, fine-grained, siliceous limestone.

In other localities the limestones of the lower portion of the series are notably crystalline, and near the axis of the Black Range at Kingston and in the Carpenter district they are essentially marbles, often mottled blue and white. In these crystalline beds no fossils have been found. The upper members are in part composed of thin cherty beds. A stratum of quartzite from 3 to 5 feet thick is present in places near the top of the series, but is not persistent.

Fossils are fairly abundant in the upper part of these limestones. Corals are most common, and at Silver City brachio-

* Ransome, F. L., Prof. Paper, U. S. Geol. Surv., No. 21, p. 33.

pods are plentiful just above the most cherty beds. Both the corals and the brachiopods belong in the Richmond division of the Upper Ordovician.

The character of transition of the rocks of this system into those above is not yet wholly established. Locally the upper portion of the limestone series is coarsely brecciated, the beds being composed of blocks of various sizes up to 10 feet in breadth and the spaces between filled with calcareous material derived from the disintegration of the same beds. The disturbance appears in some instances to have involved a bed of quartzite or gritstone, fragments of which occur along with those of the limestone.

In Sierra County the surface of the limestone is undulating or billowy, and over considerable areas the topmost layer is altered to a highly siliceous rock, in places quartzose and drusy, in others constituting a flint breccia. In some cases the silicification and brecciation was observed to extend along cracks downward into the lower limestone beds, which fact, taken in connection with other facts touching the nature and occurrence of the phenomena, warrants the conclusion that the silicification has been effected by hot waters coming up from below and spreading out along the contact with the overlying impervious shales. The silver deposits at Kingston and in adjoining districts occur in the upper part of this limestone.

Whether the coarse brecciation and billowy surface represent a kind of unconformity caused by a retiring of the waters following a period of limestone formation, as suggested by Chamberlin,* or whether it is due to underground solution, crustal movement, or to some other cause, we are as yet unable to decide.

At Silver City a perplexing feature of different character arises. In the 870 feet of limestones which overlie the Cambrian quartzites, there is no visible stratigraphic break; and in the upper 420 feet, no lithologic difference has been noted, yet in the lower part of this 420 feet are found Ordovician fossils, while near the top a Silurian fauna is present. It should be said that the rocks at this critical point are not so well exposed as they are at most places in the section, and that the original character of the limestones is somewhat obscured by impregnation of ore-bearing minerals and by their decomposition products. It may be added that in the Clifton district Devonian strata rest with apparent conformity on the Ordovician limestones, while in the Bisbee region both Ordovician and Silurian are absent although there is no structural break in the stratification.

* Geology of Wisconsin, vol. 1, pp. 138–140.

Silurian.—The general position of the rocks belonging in this system, which have been identified only in the Silver City region, and at Lake Valley, has already been stated. They occur at the upper part of a series of limestones which throughout the greater portion contain Ordovician fossils. In this upper portion, near Silver City, close to the top, are found pentameroids and other brachiopods which Mr. Ulrich places in the Silurian and regards as the equivalent of the Silurian horizon found in the Franklin Mountains near El Paso. These rocks, as has been said, differ little if any in appearance from Ordovician rocks underlying, and hence the bottom limit of these Silurian rocks is not definite. Since corals considered to be Ordovician have been found within a hundred and fifty feet of the top of this limestone series, an arbitrary thickness of 100 feet is assigned to the Silurian. It is possible that small thicknesses of Silurian strata occur at other places in the territory and have been overlooked; but it is more reasonable to suppose that they are absent, and the Silver City region thus stands as the only locality of Silurian rocks in western New Mexico or eastern Arizona. The silver deposits of Chloride Flat, near Silver City, are situated in the topmost portion of this limestone.

Devonian.—Where Silurian rocks are absent, Devonian strata rest directly upon the Ordovician limestones. In some places there is a well-marked unconformity at this horizon but in others no unconformity is apparent. Where the Devonian rocks overlie the Silurian at Silver City, the succession of sedimentation seems to have been perfect. The formation, which has a maximum thickness of 465 feet, consists almost wholly of shales and presents two well-marked divisions, the lower composed of black carbonaceous fissile shales, and the upper of blue shales which weather to a buff or brownish red color, and are more or less calcareous. In Sierra County the black shales are from 100 to 200 feet thick, but at times vary greatly in thickness within short distances due to the uneven character of the limestone surface upon which they rest. No fossils have been discovered in these lower or black shales. At Lake Valley they have heretofore been included in the Lower Carboniferous.* In the same region the upper or blue shale division has a thickness of 50 to 100 feet and in places is highly fossiliferous, notably at Kingston and 2 miles east of Hillsboro, where the beds contain brachiopods in profusion. Fossils were also known to occur between the Santa Rita and Georgetown districts. Dr. George H. Girty of the Geological Survey, to whom the fossils were referred, states that the fauna is characteristically Upper Devonian and adds that it is one of peculiar interest

*Cf. Clark, E., loc. cit.

inasmuch as it is the same which was discovered years ago in the Ouray limstone in southwestern Colorado by Mr. Endlich. It is characterized by the large and striking species *Camarotœchia endlichi* Meek, and heretofore has not been recognized outside of the San Juan Mountains.

At Silver City the Devonian system is represented by fissile shales,—about 200 feet of black shales at the bottom followed by 260 feet of red shales, in neither of which have fossils been found.

It may be added that the Devonian system is not represented in the Franklin Mountains of Texas, but is present in eastern Arizona.

Carboniferous.—In the northern half of New Mexico, where the pre-Cambrian complex is overlain by sediments, the lowest and oldest stratified rocks are Carboniferous. The work of the past summer indicates that in these instances, with possibly one or two exceptions, the Pennsylvanian division of the Carboniferous lies at the base of the section. It is interesting to note, however, that wherever the lower Paleozoic rocks are present, the Mississippian or Lower Carboniferous strata separate the Devonian from the Pennsylvanian rocks. This is the well known Mississippian fauna which was first recognized in New Mexico in the Lake Valley mining district.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Carbon Suboxide.*—From certain results that they had obtained by the action of phosphorus pentoxide upon nitrogenous organic compounds, Diels and Wolf were led to investigate the action of this oxide on ethyl malonic ester, an organic substance containing no nitrogen. As a result a remarkable compound free from hydrogen was obtained, which is actually a new oxide of carbon C_3O_2, or, structurally, OC : C : CO. The reaction taking place is represented by the equation

$$CH_2(CO_2C_2H_5)_2 = 2H_2O + 2C_2H_4 + OC : C : CO.$$

This action is brought about by distilling the malonic ester at a diminished pressure of 12^{mm} and passing the vapor through a large bulb containing phosphorus pentoxide distributed upon glass wool and heated to about 300°. Any unchanged ester is condensed in a well cooled receiver, while the more volatile ethylene and carbon suboxide are condensed in a second receiver by means of liquid air. The ethylene is finally allowed to evaporate and the carbon suboxide is purified by distillation at a low temperature. The formula was established by elementary analysis, vapor density determination, and by the explosion of a measured volume of the vapor with an excess of oxygen in a eudiometer. Practically no contraction took place after this explosion, and three volumes of carbon dioxide were formed, as shown by the equation

$$C_3O_2 + 2O_2 = 3CO_2.$$

The new compound is a colorless, highly refracting liquid having a powerful, unendurable odor. It boils at +7° and solidifies at a low temperature. The vapor violently attacks the eyes and respiratory organs, and is evidently very poisonous. It burns with a very smoky flame which shows a blue border. In its reactions it behaves as an anhydride of malonic acid, readily forming this acid when brought into contact with water. Upon being kept in a sealed tube it undergoes spontaneous decomposition, with the formation of red products which are evidently complex in their nature. The decomposition takes place almost instantly at 100°.—*Berichte*, xxxix, 686. H. L. W.

2. *New Method for the Quantitative Determination of Halogens in Organic Compounds.*—Vaubel and Scheuer have devised a method for this purpose, which is applicable to many substances, and which appears to be simpler and more convenient than the methods now in vogue. About 0·2 to 0·5 g of the substance is weighed out into a dry fractioning bulb, the side tube of which is attached rather low down on the neck and slants upward at first to serve to some extent as a reflux con-

denser for sulphuric acid. The side tube then turns down perpendicularly and is connected with a Volhard's flask (a conical flask with a triple-bulb connected to it near the bottom). The Volhard's flask is charged with an aqueous solution of silver nitrate into which the delivery tube does not dip. To the fractionating flask containing the substance is attached a dropping funnel, the stem of which reaches nearly to the bottom of the flask, by means of an ordinary cork, or better with a ground glass connection, and by means of this 30 to 50^{cc} of concentrated sulphuric acid are delivered upon the substance. The acid is gradually heated with aspiration of air through the apparatus during the heating or at the end of the operation as occasion may require. In cases where bromine or iodine are set free a little filter paper or metallic copper is used with the substance in order that enough sulphur dioxide may be produced to reduce these substances. After the halogen acid or free halogen has been distilled over, the liquid in the receiver containing the silver halide as well as much silver sulphite is transferred to a beaker, treated with considerable water and 50^{cc} of concentrated nitric acid and heated gradually at first, and finally strongly. The silver halide is collected and weighed as usual.—*Chemiker Zeitung*, xxx, 167. H. L. W.

3. *The Distillation of Metals of the Iron Group.*—Moissan has continued his investigations upon the boiling and distillation of metals, and finds that the metals of the iron family have very different boiling points. Manganese is the most volatile of all, and it distils easily at a lower temperature than lime. Next comes nickel, which boils quietly; then chromium, which distils in a regular manner with a current of 500 amperes and 110 volts. It is more difficult to boil iron, and before boiling takes place there is a tumultuous disengagement of gas which the metal has taken up, but with a current of 1000 amperes and 110 volts 400^{g} of iron were distilled in 20 minutes. Uranium has a higher boiling point than iron, while uranium and tungsten are still more difficult to bring to boiling. The latter metal could only be brought to regular ebullition by the use of a current of 800 amperes and 110 volts after an exposure of 20 minutes.—*Comptes Rendus*, cxlii, 425. H. L. W.

4. *Atomic Weight of Radium.*—The question as to whether this atomic weight is 225 as determined by Mme. Curie by a chemical method, or 258 as found by Runge and Precht from a study of the spectrum, has been discussed by H. C. Jones. He shows clearly that no valid objection can be raised to the higher value on the ground of position in the periodic system, for the higher number readily allows it to be placed in the group with barium, but in a series below the one in which it would be placed as 225. He prefers the higher atomic weight on the ground that he believes that the greater the mass of the atom, the less is its stability and consequently the greater is its radio-activity. This view is contrary to Rutherford's conception of the transforma-

tions of the radio-active elements, but Dr. Jones brings forward the argument that radium is not formed *directly* from radium, and favors the view that the production of radium is a product of synthesis, not of mere decomposition. The question can be finally settled only after a considerable amount of pure radium material is available, and some time must elapse before this is realized.—*Amer. Chem. Jour.*, xxxiv, 467. H. L. W.

5. *Mechanical Separation of Organic Substances.*—BORDAS and TOUPLAIN have applied a novel method for the detection of adulterations and impurities in chocolate, which will probably be applicable in other cases. The insoluble matter freed from fat was treated with liquids of increasing densities, from 1·340 to 1·600, made by mixing carbon tetrachloride and benzine, in such a manner that successive portions were caused to float when whirled in centrifugal tubes. The different ingredients were thus readily distinguished by their colors, they could be collected upon filters and weighed, and then be subjected to microscopic examination. Oil-cake, germs, shells, potato-starch, and mineral-matters were thus easily separated in the case of chocolate.—*Comptes Rendus*, cxlii, 639. H. L. W.

6. *Constitution of the Electron.*—W. KAUFMANN, whose experimental proof that the mass of the electron increases with its velocity, and that this mass is probably largely electrical, has been prompted by late theoretical discussions to repeat his work with a view of determining which theory best explains the experimental results. The theories he takes are those of Abraham, Lorentz and Bucherer. The theory of Abraham may be called the theory of the rigid electron, in which the field of the electron extends outwardly to infinity and within to the surface of a sphere of constant radius a; and the Maxwellian equations relating to a solid sphere with surface or volume charge in space are employed. H. A. Lorentz assumes (Versl. Kon. Akad. Wett. Amsterdam, 27 May 1904) that the dimensions of all bodies, including the molecules and the electrons, change their dimensions with velocity; and that mechanical mass changes in the same or analogous way as that of the electron. Bucherer supposes that the electron undergoes a deformation, keeping a constant volume. He makes use of the so-called "Heavyside ellipsoid," and can translate his theoretical results into those of Lorentz by this theory of deformation.

Kaufmann employs in his experiments a crystal of radium bromide, submitting its β-radiations to both electrical and magnetic fields; and carries out the research with remarkable skill. His entire apparaus can be clasped in a man's hand, and the almost microscopic details are carried to great perfection. He arrives at the result that Abraham and Bucherer's theories agree better with the experimental results than that of Lorentz. The ratio of charge to mass deduced from the various theories are as follows:

$$\frac{e}{\mu_0} = 1{,}878.10^7 \quad \text{Abraham}$$
$$\text{“} = 1{,}876.10^7 \quad \text{Bucherer}$$
$$\text{“} = 1{,}881.10^7 \quad \text{Lorentz}$$

—*Ann. der Physik*, No. 3, 1906, pp. 487–553. J. T.

7. *Retardation of the Velocity of the a Particles in passing through Matter.*—Professor Rutherford gives a preliminary note on this subject. He has repeated his former results, and concludes that further experiments confirm them. An active wire was coated with radium C. The velocity of the *a* particles was found to decrease in passing through aluminum. The lowest value of the velocity observed was $\cdot 64V_0$, where V_0 is the initial velocity of projection of the *a* particles from the bare wire. The value of $\frac{e}{m}$ for the *a* particle from radium C after passing through a screen equal in absorbing power to $5 \cdot 5^{cms}$ of air, was found to be the same as for the *a* particle of the bare wire. This experiment shows that the *a* particle retains its charge and mass unaltered over a great part of its range in air.—*Phil. Mag.*, April, 1906, pp. 553–554. J. T.

8. *Electrical Conductivity of Flames containing Salt Vapors for alternating currents.*—For rapidly alternating currents a flame containing an alkali-salt vapor behaves like an insulating medium having a high specific inductive capacity. The view is confirmed that the negative ions from all salts have the same velocity. Not more than one molecule in 30 salt molecules is ionized at any instant in the flame, but each molecule is probably ionized and recombines several million times per second. The steady currents observed through salt vapors in flames are very far from the maximum possible currents corresponding to the number of ions produced per second. The paper is a full one and is by Prof. N. A. Wilson, and E. Gold.—*Phil. Mag.*, April, 1906, pp. 484–505. J. T.

9. *Electrically prepared Colloidal Solutions.*—The size of the diameters of the particles of gold, silver and platinum in electrically prepared colloidal solutions lies between the limits $(2-6)\times 10^{-5}$ cms. The electro-negative, non-oxidizable metals, gold, silver and platinum, give solutions in water and ethyl malonate, in which the particles are negatively charged. The electro-positive, oxidizable metals give solutions in water, methyl alcohol and ethyl alcohol, in which the particles are always positively charged. The velocity of the particles under a known electric force have been determined and the potential differences between the liquid and the particle have been deduced by using the formula $V = \frac{4\pi}{K} \cdot \frac{\mu v}{X}$.—E. F. Burton, Cavendish Laboratory, *Phil. Mag.*, April, 1906. J. T.

10. *Recombination of Ions in Air and other Gases.*—Among the large number of important papers on ions in the April num-

ber of the Philosophical Magazine is a very suggestive one by Prof. W. H. BRAGG and Mr. R. D. KLEEMAN on this subject. They conclude in the main that (1) the range varies inversely as the pressure; (2) that the total number of ions set free in a gas is independent of the pressure, but is different in different gases. —*Phil. Mag.*, April, 1906. J. T.

11. *Nucleation of the Atmosphere.*—The subject of the nucleation of the atmosphere, discussed by C. Barus in a series of papers published in this Journal (volumes xiii to xx) is treated at length by the same author in the following exhaustive memoirs :

A Continuous Record of Atmospheric Nucleation ; pp. xvi, 226, from volume xxxiv of the Smithsonian Contributions to Knowledge. The investigation was carried on with the aid of a grant from the Hodgkins Fund.

The Nucleation of the Uncontaminated Atmosphere; pp. xii, 152. Publication No. 40 of the Carnegie Institution of Washingon

II. GEOLOGY AND MINERALOGY.

1. *Geology ;* by THOMAS C. CHAMBERLIN and ROLLIN D. SALISBURY. In three volumes, *Vol. II, Earth History, Genesis–Paleozoic*, pp. xxvi, 677 and index, with geological map of the United States compiled by Bailey Willis, numerous paleogeographic maps and other illustrations. *Vol. III, Earth History, Mesozoic–Cenozoic*, pp. xi, 578 and index to vols. i, ii, iii. Maps and illustrations, as in the preceding volume. New York, 1906 (American Science Series, Advanced Course. Henry Holt & Co.). —Since the publication of Vol. I of this work in 1904, with its able and original discussions of earth processes, every geologist has awaited with much interest the completion of the series. This interest has been justified, for the volumes now issued are conspicuous, even more than the first, for the many original points of view and the radical departure from the older manuals both in methods and subject matter. This series will doubtless give a marked stimulus to investigation for the forthcoming decade. This is partly due to the fact that the volumes look forward rather than backward, an unusually large place being given to working hypotheses, while unsolved problems are frankly recognized and the student is carried along with the investigator to the still debatable ground.

The chief innovations are found in the chapters devoted to "Hypotheses of Earth Origin" (81 pp.), and "Hypothetical Stages leading up to the known eras" (50 pp.). The Proterozoic, a name long since proposed by Irving, is used as the approximate equivalent of the Algonkian and 55 pages are given to this era. Ordovician is fully adopted in place of the long-contested name of Lower Silurian ; the Subcarboniferous for the first time in a text-book is given the dignity of a separate period of equal rank with the Devonian, and called the Mississippian ; the true Carboniferous becoming the Pennsylvanian. The lower Cretaceous

is similarly separated into the Comanchean, of equal rank with the Jurassic and Cretaceous. The discussions are based upon the doctrines of the permanency of continents and that of the world-wide character and periodicity of the great deformative movements, the latter being used as the basis for the separation of the Mississippian and Comanchean. The problems of the Permian and Pleistocene receive considerable attention, the former occupying 59 pages, much in small print, and the latter 190 pages.

As stated in the preface "the familiar calling of the biological roll under each period is abandoned, and will perhaps be missed." The paleontological side of the earth history is subordinated in space to the paleogeographical and the problems dealt with are chiefly the origins and mutations of the faunas and floras.

From the preceding necessarily brief statements it is seen that these volumes are strikingly radical and stimulating both in their method of treatment and in the subject matter. For these reasons, however, they do not supplant the standard manuals at present before the public, but rather supplement them. Taken in connection with Dana's Manual and the fourth edition of Geikie's Text Book, the advanced student is, at present, admirably provided with condensations of geological knowledge. The authors state that the "three volumes are designed to furnish the basis for a year's work in the last part of the college course, or in the early part of a graduate course." Many teachers, however, may question whether such students are sufficiently mature to use these volumes as texts, but they certainly furnish much lecture material for the teacher and form excellent reference books for mature students. To the young student, with an insufficient basis of facts and limited experience in their interpretation, the prominence given to hypothesis, though otherwise an excellent feature, may be dangerous, possibly leading him to neglect the detail of the science for this more attractive field. Geology is a science which has suffered much in the past from ungrounded speculation, since speculation is easier than investigation, and interpretations must be largely based upon the unseen. These volumes, however, should be carefully read by every advanced student in geology and no teacher can consider himself abreast of the times until he has become familiar with them. They will also be found intelligible and interesting by men in other branches of science. J. B.

2. *Traité de Géologie;* par A. DE LAPPARENT. 5th edition in three volumes, 2015 pages. Paris, 1906 (Masson & Co.).—This elaborate work of the eminent French geologist and geographer, considerably enlarged from the previous edition, suggests a comparison with the three-volume Geology of Chamberlin and Salisbury, lately completed. De Lapparent devotes one volume to "phénomènes actuels," morphology, physiography, erosion, volcanoes, earthquakes and so on, and two volumes to "géologie proprement dite," under which an elaborate review of historical geology is presented, covering all parts of the earth,

although Europe is naturally more fully treated than the other lands. While one cannot expect to find in a general work of this kind detailed accounts of all topics, nevertheless the space given to many problems suffices to place them definitely before the student; for example, the changes of level along the coast of Holland and Flanders in historic times are well summarized near the end of the first volume. Among the features of the work that will excite much attention are the maps of the world, on which the successive formations are charted, and on which lines are drawn, even across the oceans, to indicate in a general way the probable division of land and water in different epochs. Thus it is brought forth in a striking manner, that eastern South America, nearly all Africa, southern Asia, and much of Australia agree in lacking marine deposits during long consecutive periods; they are therefore looped together and regarded as parts of a great unit. Although there must be much of speculation in such maps, as no one can know better than the author, they perform a great service in giving the student a rapid summary of facts of distribution, to be amplified by the text. The evolution of terrestrial relief is treated near the end of the third volume, where among other reasons for not accepting Suess' theory of horsts, a strong point is made of the long persistence of littoral conditions in certain districts (as in N. W. France), for such persistence would not be a natural consequence of Suess' views. W. M. D.

3. *Coon Butte, Arizona, and the Canyon Diablo Meteorites.*— Recent papers on this subject by D. M. Barringer and B. C. Tilghman give a detailed description of the crater-like form of Coon Butte, and reaffirm with confidence the hypothesis early suggested that it was formed by the impact of an enormous meteorite falling with something like its original planetary velocity.* As is well known, this region has afforded many thousand masses of meteoric iron varying in weight from a thousand pounds and more down to a few ounces, the total amount aggregating, it is stated, more than ten tons. Further, since the gentlemen above mentioned have taken possession of the property, their search has revealed several thousand additional masses, aggregating more than a ton. The various remarkable features of the iron are too well known to need to be rehearsed here, but it is interesting to note that Professor J. W. Mallet has found both platinum and iridium in samples of residues from solution in hydrochloric acid. Besides the iron, large quantities—a ton or more in weight—of magnetic oxide of iron have been found distributed over the surface of the rim and the surrounding plain. This "iron shale" contains nickel, iridium, and platinum, and

*The theory, advanced in 1896 by G. K. Gilbert, that "the crater, although exhibiting no volcanic rock, is essentially volcanic, having been produced by an explosion of steam generated by some subterranean volcanic intrusion," has hitherto been generally accepted. See G. K. Gilbert, in U. S. G. S., 14th Ann. Rep., I, 187, also Science, iii, 1, 1896.

apparently in the same proportion as in the meteorite itself, from which it is believed it was derived. Similar material, consisting of magnetite in various forms, was also found within the crater at depths varying from 300 to 500 feet. Part of this was in form of small spherules or "shale balls"; these showed a nucleus of metallic iron with an envelope of magnetite. The character and distribution of this magnetic oxide, the latter similar to that of the masses of iron, furnish the authors with confirmation of the meteorite hypothesis as to the origin of the crater. Further confirmation is found in the distribution of the masses of meteoric iron found, in the large amount of minutely pulverized silica, as well as fragments of limestone, within the crater, and in the absence of volcanic rocks or volcanic phenomena from the immediate region. The meteoric masses have been found distributed over a crescent-shaped area surrounding the hole and concentric with it, extending from northwest to east. Only two or three masses of the iron have been found within the crater itself. A number of borings with the diamond drill were made in the effort to locate the supposed mass or masses within the crater, one of these to a depth of over 1000 feet. Several of them met with an obstruction of undetermined nature, which was believed to be the expected meteorite. The authors state that they have already begun to sink a shaft in the center of the crater and that they propose to carry it, if possible, to a depth sufficient to settle the question beyond all possibility of doubt. It is much to be hoped that this plan will prove practicable and that it may be carried to a successful conclusion. It would be a matter of extraordinary and unique interest to establish positively the truth of the hypothesis named.

It is interesting to note, also, though not immediately connected with the subject in hand, that a meteoric stone was found by Mr. Barringer in June, 1905, not far from Coon Butte; this is described by Professor Mallet on an earlier page of this present number.—*Proc. Acad. Nat. Sci. Philad.*, pp. 861–904, 1905.

4. *Geology of the New Hebrides;* by D. Mawson. Proc. Linn. Soc. N. S. Wales, 1905, pt. 3, pp. 400–485, pls. 15.—For the benefit of the general reader it may be said at the outset that the New Hebrides are an island group in the Pacific between lat. 14° and 21° S. and long. 168° and 170° E. They are mountainous, partly volcanic, heavily wooded, unhealthy, inhabited by about 50,000 natives, of Papuan stock, governed by a mixed commission of English and French naval officers. Area about 5100 square miles, divided among 12 principal islands. The larger islands are high and show extensive exposures of volcanic rocks underlying areas of raised coral formations, the latter showing in places elevations of nearly 2000 feet. The smaller islands are sometimes volcanic, sometimes of coral formation. There are several active volcanoes in the group. The author describes these geological features, listing the Miocene fossils in the bedded rocks and giving in detail the petrography of the lavas. We quote the following analyses made by him:

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O+
I	63·60	15·84	1·45	2·72	1·14	3·03	4·33	3·26	3·88
II	46·78	21·22	4·63	6·17	4·30	12·07	1·40	0·64	0·94
III	43·98	17·69	5·97	6·68	7·83	11·71	1·34	0·64	1·77
IV	60·96	16·62	3·87	2·61	0·95	6·35	3·01	3·40	1·03

	H_2O-	CO_2	TiO_2	P_2O_5	Cr_2O_3	MnO	Cl	Total	Sp. gr.
I	0·30	none	0·70	0·10	tr.	tr.	tr. =	100·35	2·51
II	0·50	tr.	1·20	0·31	0·05	tr.	tr. =	100·21	2·90
III	0·95	tr.	1·20	0·32	0·05	tr.	tr. =	100·13	2·95
IV	0·18	0·10	0·50	0·25	0·04	tr.	tr. =	99·87	2·54

I Hypersthene andesite perlite (adamellose) Leleppa Island.
II Basalt porphyrite (hessose) Mau Island.
III Basalt porphyrite, dike (auvergnose) Fatmalapa, Efate Island.
IV Hornblende andesite (harzose) Wai Malikoliko, S. W. Santo.

In concluding the author notes that the coral formations in recording crustal movements have developed three main types of islands corresponding to as many possible land-movements.

First, in regions of *continuous upheaval*, islands veneered with coral limestone terraces like the New Hebrides.

Second, on *subsiding areas*, islands which are typical atolls like those of the Ellice group.

Third, in regions of *both upheaval and subsidence*, islands in which coral limestones are interbedded with volcanic submarine tuffs or other products; seen in the larger islands such as Viti Levu of the Fiji group.

The work is accompanied by a number of maps and interesting photographs of the island scenery, rock sections, etc., and is an excellent contribution to Pacific geology. L. V. P.

5. *Salient Geological Features of British New Guinea;* by A. G. MAITLAND, West Aust. Nat. Hist. Soc., April 11, 1905, 26 pp.—This gives a brief résumé of the observations made by the author in a trip along the coast in a Government vessel with excursions inland. It was found that the coastal districts and many of the adjacent islands were composed of extinct volcanoes and their ejections and on the northeast coast and the Louisade Archipelago of horizontal limestones, upraised coral formations. A large portion of the backbone of the mainland is formed of ancient crystalline rocks with bedding at high angles. The country is beginning to yield an increasing amount of gold, amounting in the year 1902–03 to over $200,000. L. V. P.

6. *Geological Survey of Canada:* ROBERT BELL, Director. —The following publications have recently appeared:

ANNUAL REPORT, Part B. Report on the Klondike Gold Fields; by R. G. MCCONNELL. Pp. 71, with colored map. This gives the results of field work carried on during the season of 1903.

Part J. Report on the Geology of a Portion of Eastern Ontario; by R. W. ELLS. Pp. 89, with colored map.

Recent Mineral Discoveries on Windy Arm of Tagish Lake, Yukon; by R. G. MCCONNELL. Pp. 12. The quartz veins described carry various silver and copper ores.

The following valuable maps have been issued by the Department of the Interior, JAMES WHITE, Geographer.

Relief Map of the Dominion of Canada, scale 100 miles to one inch.

Resource Map of the Dominion of Canada with statistics of productions, scale 197·3 miles to an inch.

Standard topographical Map, Ontario, Windsor sheet, sheet 1, S.W.

7. *Mica: its Occurrence, Exploitation and Uses;* by FRITZ CIRKEL. Pp. 148, with colored map. Ottawa, 1905. Mines Branch, Department of the Interior.—This bulletin is similar in scope to the one on asbestus before noticed (p. 255) and also deals with a very important industry. In 1902, Canada ranked next to India in the production of mica, yielding nearly an amount valued at $250,000, or about one-quarter of the world's supply. The mica is, in part, muscovite, which is obtained from pegmatite veins or dikes in the Laurentian formation, the best deposits being those of the Saguenay District on the Lower St. Lawrence, with others north of Ottawa and elsewhere. A considerable part of the mica, however, is obtained from phlogopite, workable deposits of which are confined to Canada. These deposits exist particularly in an area of 520 square miles included in the country north of Ottawa, in the townships of Burgess, Lanark and Loughborough, province of Quebec. The horizon of mica deposits is confined to the upper portion of the Laurentian siliceous rocks which underlie the limestone proper. These gneisses are generally of gray or reddish gray appearance, with hornblendic bands, nearly all of which are highly siliceous. These beds penetrate through the calcareous layers into the massive crystalline limestone formation. In the Buckingham and Templeton areas, apatite and mica are seldom found in the crystalline limestone, but in the Gatineau area several large dikes of pyroxene occur in this formation, carrying workable mica deposits. Two classes of deposits are distinguished: 1. Contact deposits, forming the contact between the gneiss and pyroxene, and 2. pocket deposits, occurring in fissures wholly in pyroxene, or on the contact between intrusive feldspar or diorite and pyroxene. The former deposits are the most important from a mining point of view.

8. *Beiträge zur Mineralogie von Japan*, No. 2, pp. 23–74.—The second number of the Contributions to the Minerology of Japan, edited by T. Wada, contains several mineralogical papers, one of which, on crystals of the new mineral naegite (this Journal, xix, 90), deserves special mention. A paper descriptive of Japanese meteorites by K. Jimbo is also important, giving new facts and correcting various errors in foreign catalogues as to time and place of fall. It is stated that thirty metorites have thus far been discovered in Japan, representing sixteen distinct falls; most of these are stones.

9. *Studies in Fluorite.*—A recent paper by HARRY W. MORSE discusses in detail the fluorescence and thermo-luminescence of fluorite and also the nature of the gaseous and liquid inclusions.

Although many interesting results are obtained, no explanation is arrived at for the luminescence of the mineral; it is concluded that there is no proof that the organic substance present in the mineral, to which the color is probably due, has anything to do with the fluorescence and the thermo-luminescence. The regeneration of the latter power of chlorophane seems to indicate that a part of the emitted light at least has an inorganic source. —*Proc. Amer. Acad.*, xli, No. 27, March, 1906.

10. *International Geological Congress.* — The tenth annual meeting of the *Congrès Géologique International* will be held in the City of Mexico from September sixth to thirteenth. A most interesting series of excursions is announced in the preliminary circular.

III. Miscellaneous Scientific Intelligence.

1. *National Academy of Sciences.*—The Spring meeting of the National Academy of Sciences was held at Washington on April 16–18; thirty-four members were in attendance. The following gentlemen were elected members of the Academy: Benjamin O. Peirce, of Cambridge, Mass.; W. B. Scott, of Princeton, N. J.; and Josiah Royce, of Cambridge, Mass. Prof. Wilhelm Ostwald, of Leipzig, and Prof. H. A. Lorentz, of Leiden, were elected foreign associates. The Draper medal was presented to W. W. Campbell of the Lick Observatory at a dinner given by Professor Alexander Agassiz at the new Willard Hotel on April 17th.

The following is a list of the papers presented at the meeting:

J. McK. Cattell: The distribution of American men of science.

C. S. Peirce: Recent developments of existential graphs and their consequences for logic.

Theo. Holm: Commelinaceæ. Morphological and anatomical studies of the vegetative organs of some North and Central American species.

A. Agassiz and H. L. Clark: On the classification of the Cidaridæ.

Theo. Gill: Interference of oviposition of a Sargasso fish with a flying fish.

H. F. Osborn: Faunal and geological succession in Eocene and Oligocene Basins of Rocky Mountain region.

W. J. Sinclair: Volcanic ash in the Bridger Beds of Wyoming.

C. E. Dutton: Radio-activity and volcanoes.

C. D. Walcott: Cambrian faunas of China.

George E. Hale: Recent solar investigations.

W. W. Campbell and C. D. Perrine: Some recent solar eclipse results.

M. I. Pupin: Feeble, rapidly alternating, magnetization of iron.

J. M. Crafts: Primary standards for temperature measurements between 100° and 350°.

Asaph Hall: Biographical memoir of Admiral John Rodgers.

W. M. Davis: Biographical memoir of George P. Marsh.

Theo. Gill: The life history of Pterophryne.

2. *The Franklin Bi-Centenary.*—A General Meeting of the American Philosophical Society was held at Philadelphia on April 17–20 in celebration of the two hundredth anniversary of the birth of Benjamin Franklin. The introductory exercises were held on Tuesday (17th); Wednesday was devoted to the

reading of original papers on scientific subjects, and the special commemoration exercises and addresses were given on Thursday and Friday. The occasion was throughout one of the very highest interest.

3. *Chemistry of the Proteids;* by GUSTAV MANN. Based on Professor Otto Cohnheim's 'Chemie der Eiweisskörper.' 1906. Pp. 606. London and New York, 1906 (The Macmillan Co.).—The publication of an important volume exclusively devoted to the proteid substances, within two years after the appearance of the second, enlarged edition of Cohnheim's Eiweisskörper, brings evidence of the growing interest which the newer knowledge of the albuminous substances has begun to awaken. Dr. Mann's book, although primarily based upon the well-known German compilation, can justly lay claim to considerable original merit in addition to that of a successful translation; for aside from bringing the literature practically up to date, the author has both revised the German version and somewhat extended its scope. Among the more important innovations may be mentioned: the physiological considerations (somewhat concise) introduced in connection with several aspects of the chemical study of the proteids; the more detailed discussion and interpretation of physico-chemical problems here concerned and in which Dr. Mann departs at times from Cohnheim's views; a valuable résumé of the chemistry of the autodigestion of nucleoproteids and its attached significance; a well-arranged digest of the very recent work on the synthesis of compounds of the polypeptid type; additional references to the historical aspects of the included topics.

It is impossible to subject the vast array of detailed information to a critical review here. Sufficient must be the praise to which the painstaking and distinctly critical (though unbiased) efforts are richly entitled to. Dr. Mann's book will be an almost indispensable reference work in the physiological laboratory; and it is likely to do commendable service to biological science by affording to those less conversant with its chemical problems a more ready opportunity to become acquainted with its progress and present status—to study the cell as "a chemical and physico-chemical mechanism." L. B. M.

4. *Wilhelm Fliess und Seine Nachentdecker, O. Weininger und H. Swoboda;* von RICHARD PFENNIG. Pp. 66. Berlin, 1906 (Emil Goldschmidt).—This monograph is a defence of the priority claims of Fliess in respect to the formulation and publication of his somewhat startling theories of the "permanent bisexuality" characterizing living things and the periodicity of biological processes. It therefore possesses little more than polemical value.

5. *The Lagoon of Venice.*—The Venetian Institute of Science, Letters and Arts has undertaken a systematic study of geophysical phenomena which concern directly and indirectly the Lagoon of Venice. With this object a special commission has been

appointed, and the preliminary investigations, bearing principally on the tidal-waves in the upper Adriatic together with the rivers flowing into it and the lagoon of Venice, intrusted to Dr. Giovanni Piero Magrini, who is to be assisted by Professors Luigi de Marchi and Tullio Gnesotto of the University of Padua. Any publications which might prove useful in this undertaking are solicited by the President, A. Favaro.

6. *The Philippine Journal of Science.*—The second number of volume one of this new periodical (see xxi, p. 336) has been recently issued, accompanied by Bulletin No. 36, having the title: A Hand-list of the Birds of the Philippine Islands; by Richard C. McGregor and Dean C. Worcester. Pp. 123.

7. *Field Columbian Museum.*—The following publications have been recently issued:

Botanical Series, Vol. II, No. 3, Prænunciæ bahamenses—I. Contributions to the Flora of the Bahamian Archipelago; by C. F. Millspaugh. Pp. 137–184.

Report Series, Vol. II, No. 5. Annual Report of the Director, Frederick F. J. Skiff, to the Board of Trustees for the year 1904–1905. Pp. 333–435, plates lxi–lxxi.

La Matiére, sa Naissance, sa Vie, sa Fin; par P. De Heen. Pp. 119, with 61 figures. Bruxelles, 1905, Hayes (Imprimeur des Académies Royales de Belgique).

Nouvelles Orientations Scientifiques: Ouvrage traduit du catalan avec l'autorisation de l'auteur; par J. Pin Y. Soler. Pp. 164, with 36 figures. Paris; 1905 (Garnier Frerès, Editeurs).

The Universal Kinship; J. Howard Moore. Pp. 329. Chicago, 1906 Charles H. Kerr & Co.).

Obituary.

James Mills Peirce died suddenly in Cambridge on the 21st of March, 1906, in the 72d year of his age.

A member of the faculty of Harvard College for nearly 50 years, he served the University as Tutor in Mathematics, as Assistant Professor, and as Professor and Dean of The Graduate School and Dean of The Faculty of Arts and Sciences.

He was remarkable for the breadth and depth of his scholarship and for the thoroughness and finish of his work whether as lecturer, legislator, or administrator, rather than for his scientific productiveness. His students knew him as a helpful friend and as an inspiring teacher, his associates as one of the most genial and lovable of men. W. E. B.

Nathaniel S. Shaler, Professor of Geology in Harvard University and Dean of the Lawrence Scientific School, died on April 10th, at the age of sixty-five years; a notice is deferred until another number.

M. P. Curie, the French chemist and physicist, to whom, with Mme. Curie, our knowledge of radium and its properties is largely due, was accidentally killed in Paris on April 19th.

Professor Lionel Smith Beale, well known through his works on the microscope, died on March 28 at the age of seventy-eight years.

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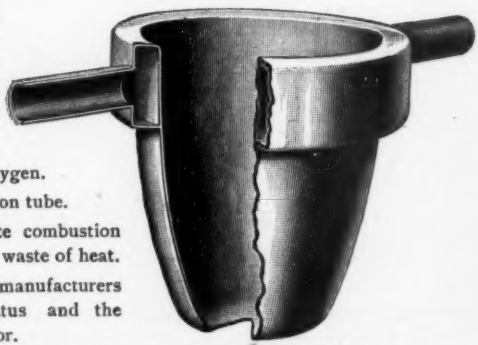

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